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Joseph L. Decell, et al

Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

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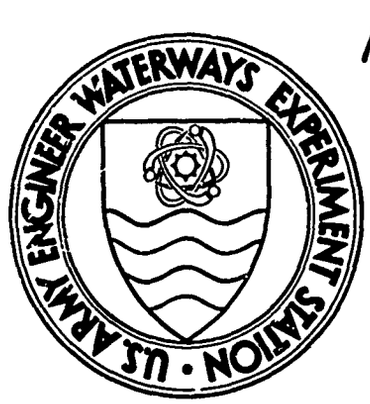

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A METHOD FOR PRODUCING QUANTITATIVELY BASED MILITARY GEOGRAPHIC INTELLIGENCE PRODUCTS FOR AN AIRMOBILE DIVISION

by

J. L. Decell, W. E. Grabau, B. O. Benn, J. K. Stoll, B. G. Stinson

July 1972

Sponsored by U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia

Conducted by U. S. Army Engineer Waterways Experiment Station
Mobility and Environmental Systems Laboratory
Vicksburg, Mississippi

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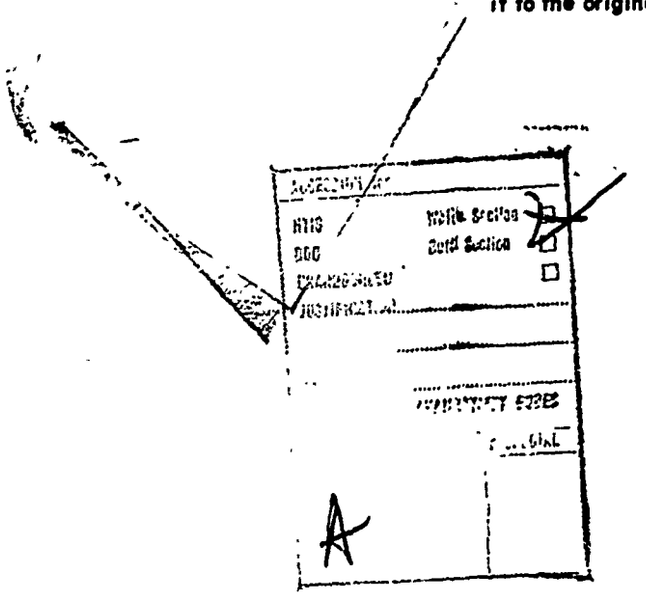

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Joseph L. Decell, Jack K. Stoll
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13. ABSTRACT

Seven prototype military geographic intelligence (MGI) products, specifically designed to meet the terrain intelligence needs of an airmobile division in a tactical situation, were developed. The development included five steps: (1) compilation of conceptual models relating the terrain to certain tactical activities; (2) identification of significant terrain factors and assignment of class ranges of their values on the basis of the requirements of the models; (3) construction of factor maps of the selected study area on the basis of the selected terrain factor classes; (4) compilation of a factor complex map for each desired MGI product; and (5) transformation of the factor complex maps to "performance prediction" maps, which were the desired end product. Schematic flow charts of the models are presented, together with lists of significant factors, tables defining classifications of factor values, and the entire array of factor maps, factor complex maps, and MGI products maps.

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Foreword

This study was part of an effort to design military geographic intelligence (MGI) products to meet specific terrain intelligence needs of an airmobile division. The participation of the U. S. Army Engineer Waterways Experiment Station (WES) in the study was sponsored by the Geographic Applications Branch of the U. S. Army Engineer Topographic Laboratories (ETL). The study was authorized by Intra-Army Order No. MERDC 194-69 under Task 9860032, dated 5 June 1969.

The study was conducted by personnel of the Mobility and Environmental Systems Laboratory, WES, under the general supervision of Messrs. W. G. Shockley, Chief, and S. J. Knight, Assistant Chief, and under the direct supervision of Mr. J. L. Decell formerly of the Vehicle Studies Branch, now of the Terrain Analysis Branch.

Photo interpretation and factor mapping were performed under the supervision of Mr. J. H. Shamburger, Chief, Military Projects Section, Geology Branch, Soils and Pavement Laboratory. The conceptual models used in this study were formulated by Messrs. B. G. Stinson and J. L. Gargaro of the Vehicle Studies Branch. This report was written by Mr. J. L. Decell, with assistance from Messrs. W. E. Grabau, B. O. Benn, J. K. Stoll, and B. G. Stinson.

Directors of WES during the conduct of this study were COL Levi A. Brown, CE, and COL Ernest D. Peixotto, CE. Technical Director was Mr. F. R. Brown.

Contents

Conversion Factors, British to Metric Units of Measurement

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
miles	1.609344	kilometers
pounds per square inch	0.00689476	megapascals (= meganewtons per square meter)

Summary

Seven prototype military geographic intelligence (MGI) products, specifically designed to meet the terrain intelligence needs of an air-mobile division in a tactical situation, were developed. The development included five steps: (1) compilation of conceptual models relating the terrain to certain tactical activities; (2) identification of significant terrain factors and assignment of class ranges of their values on the basis of the requirements of the models; (3) construction of factor maps of the selected study area on the basis of the selected terrain factor classes; (4) compilation of a factor complex map for each desired MGI product; and (5) transformation of the factor complex maps to "performance prediction" maps, which were the desired end product. Schematic flow charts of the models are presented, together with lists of significant factors, tables defining classifications of factor values, and the entire array of factor maps, factor complex maps, and MGI products maps.

A METHOD FOR PRODUCING QUANTITATIVELY BASED MILITARY GEOGRAPHIC INTELLIGENCE PRODUCTS FOR AN AIRMOBILE DIVISION

Background

1. In the past, military geographic intelligence (MGI) products have generally been designed to meet the needs of numerous potential users. Consequently, they often contain information on more subjects than any specific user needs, but seldom enough information on individual subjects that are critical to a specific user's requirements. A new concept is to produce terrain intelligence products to meet the specific needs of specialized Field Army elements, such as an airmobile division.

Objectives of Study

2. The objectives of the study reported herein were to develop the procedures required to produce a family of MGI products designed to furnish the specific information required by the commander of an airmobile division to plan and conduct certain critical tactical activities, and to produce prototype versions (maps) of these products.

Scope

3. The MGI products selected for the program were cross-country speed for vehicles, cross-country speed for personnel, helicopter landing zone (HLZ) construction effort, concealment characteristics, cover characteristics, airfield construction effort, and bunker construction effort. The prototype MGI product maps were to be constructed to a scale of 1:50,000, and were to cover a small area near Manati, Puerto Rico. For those activities for which no mathematical performance prediction models exist, conceptual models were to be prepared, but no

attempt was to be made to make such models into rigorous mathematical constructions. The emphasis of this program was on the development of new formats and concepts for MGI products, and not on the quantitative reliability of the prototypes.

4. The rationale for developing the proposed new MGI products is based on recognition of the fact that one of the most critical of the tactical commander's information needs is knowledge of the effects of the terrain on his men and equipment. That is, he needs a prediction of their performance in the proposed operational region. In the past, the predictions furnished him by the terrain analysts have been almost entirely subjective and qualitative: "cross-country going is good," "concealment potential is poor," and the like. It seems apparent that an MGI product that provided quantitative answers to the commander's questions concerning terrain impacts would be a significant improvement.

5. The acceptance of the need for quantitative predictions makes it mandatory that the predictions be based on some form of mathematically rigorous procedure. In effect, this means that the first step in the analytical process must be the development of mathematical performance prediction models of military functions to produce objective evaluations of the effects of terrain on the modeled functions. The model identifies the terrain factors that significantly affect the performance of the modeled function; those factors can then be objectively mapped in quantitative terms over the area of interest. The factor maps can then be compiled into a factor complex map that will contain the specific data required by one of the performance prediction models. The map can then be readily transformed into a performance prediction map by using the displayed terrain descriptions as input parameters to the appropriate performance prediction model.* The resulting performance prediction map becomes an invaluable tool for determining the

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* W. E. Grabau, J. K. Stoll, and B. G. Stinson, "A Plan for Quantitative Evaluation of the Cross-Country Performance of Prototype Vehicles," Miscellaneous Paper M-70-7, Sep 1970, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

magnitudes of the effects of terrain on tactical functions in any part of the area of interest.

6. The proposed procedure yields objective evaluations of the effects of terrain on military activities, and thus reduces the dependence of the commander on subjective judgments. Even given an adequate description of the terrain, few tactical commanders have the necessary skill to quantitatively evaluate all of the terrain/activity interactions that will affect the operations of his unit. In most cases, the best that can be obtained is scarcely more than a subjective and very general qualitative estimate of such interactions. In modern war, this is no longer adequate.

Approach

Selection of study area

7. The area for which the prototype MGI products were produced was selected on the basis of four considerations. First, it was believed that the area selected should offer a wide variety of terrain characteristics. Second, as much ground-truth data as possible should be available within the area, because most of the actual mapping would have to be done by photo interpretation. Third, it was essential that recent, high quality air photography at a scale of about 1:20,000 be available, so that the factor mapping would be as reliable as possible. Fourth, the area should be reasonably accessible, so that field checks of the mapping could be conducted at some time in the future, if necessary.

8. Several areas were proposed, including small regions in Puerto Rico, the Federal Republic of Germany, Thailand, the Yuma area of Arizona, and the northeastern United States. An analysis of these areas revealed that the Manati area (bounded by 66°37'30" and 66°22'30" west longitude and 18°15' and 18°30' north latitude), Puerto Rico, would best satisfy all of the requirements. Adequate map and photographic coverage was available, the terrain presented a wide variation in conditions, abundant quantitative ground-truth data were readily

available, and the area was readily accessible.

Selection of prototype MGI products

9. Through a literature search of field manuals and discussions with personnel of airmobile division units, it was determined that, following the selection of the tactical objective, the operational plans for an airmobile division operation are developed sequentially as follows:

a. Ground Tactical Plan (based on the objective)
b. Air Landing Plan (based on the Ground Tactical Plan)
c. Air Movement Plan (based on the Air Landing Plan)
d. Loading Plan (based on the Air Movement Plan)
e. Staging Plan (based on the Loading Plan)

Program restrictions were such that prototype MGI products were developed to satisfy only the first three of the operation plans (i.e. items a, b, and c, above).

10. Examination of the three operational plans (i.e. Ground Tactical Plan, Air Landing Plan, and Air Movement Plan) revealed that a major part of their terrain intelligence requirements could be met by the seven MGI products:

a. Cross-country speed for vehicles
b. Cross-country speed for personnel
c. HLZ construction effort
d. Concealment characteristics
e. Cover characteristics (weapons effectiveness)
f. Airfield construction effort
g. Bunker construction effort

Formulation of models

11. Because the end product of military terrain analysis is ideally a quantitative prediction of the performance of a military activity or item of equipment in the operational environment, it follows that the actual terrain analysis had to be preceded by the compilation of an analytical model for each MGI product. Suitable mathematical models already existed for three of the MGI products: cross-country locomotion of vehicles, HLZ construction effort, and airfield

·onstruction effort (figs. 1, 2, and 3, respectively). Since no mathematical models existed for the other four MGI products, the first effort had to be the compilation of such models. However, because the objective of the program was primarily to develop the formats of the new products and the procedures for constructing them, and not to prepare actual MGI products for tactical use, the four models were brought only to the conceptual stage. That is, they were formulated into reasonably sophisticated flow charts, but no attempt was made to complete them by converting the flow charts into completely quantitative mathematical statements. In consequence, four of the prototype MGI products (cross-country speed for personnel, concealment, cover, and bunker construction effort) are probably not intrinsically reliable, since the map unit values were obtained by somewhat subjective methods, albeit closely guided by their respective conceptual models. The four conceptual models are presented in graphic form (i.e. as flow charts) in figs. 4-7.

Terrain analysis*

12. The performance prediction models are in essence only highly formalized statements describing the interrelations among terrain factors and military activities or items of materiel. Thus, their formulation required the identification and definition of all terrain factors that are significant to the seven models. A total of 24 factors was found to be required to satisfy the input requirements of the seven models. A listing of these factors and their associations with each individual model and resulting products is shown in fig. 8.

13. Once the terrain factors were determined, class ranges were selected for each factor to be mapped. The factor classes were established by weighing several different considerations:

a. Requirements for accuracy in the predictions. If great accuracy is required, class intervals must be small; if

* U. S. Army Engineer Waterways Experiment Station, CE, "Mobility Environmental Research Study: A Quantitative Method for Describing Terrain for Ground Mobility," Technical Report No. 3-726 (Vols I-VIII), Vicksburg, Miss.

relatively general predictions are acceptable, the class intervals may be large.

b. Reliability of acquired terrain data. If the terrain data can be obtained with great accuracy, the class intervals may be small, but if the terrain data can only be obtained as estimates, the class limits must be large, and in fact ought to be as large as the "error of estimation" of the factor values.

c. Significance of the factor to the performance prediction. If the factor plays only a small role in the performance prediction, the class intervals may be large, but if the factor is a major controlling element, then the class interval should be small.

14. It is evident that the actual class intervals were obtained by a trade-off process. The factor classes ultimately selected for the 24 factors mapped in this study are presented in table 1. References and a definition relating to the origin of selected factor classes are presented in table 2.

15. Factor mapping. The general sequence of stages by which a final MGI product map is constructed is shown in fig. 9. After the significant factors have been selected, the relevant data are withdrawn from the data files. These data comprise the available "ground truth" required by the photo interpreters. The ground truth is then plotted on an overlay that can be placed on the available aerial photographs. Then, on the basis of the accuracy of the data and other considerations (as previously noted), the total range of values presented by each factor is subdivided into acceptable classes, designated "factor classes." With the plotted data as guides, the photo interpreter then delineates the areas of occurrence of each factor class, one factor at a time. Thus there are as many "factor maps" as there are significant factors in the problem (in the present instance, 24).

16. When attempts to map the various factors are made, it is quickly discovered that there are two general classes between which the analyst is forced to differentiate because of peculiarities in their occurrence. All of the factors (see fig. 8) relating to substrate characteristics, surface macrogeometry, surface microgeometry, and vegetation structure are such that their expression can be mapped as areal

distributions. The reason for this is that, in general, they tend to occur in homogeneous areas that are large enough to be readily delineated on maps of the selected scale. These factors may thus be designated "areal terrain factors." The remainder of the factors, namely those describing hydrologic geometry, occur for all practical purposes only as linear features too narrow to show as a band on the appropriate maps. The most convenient method of dealing with this problem is to map them with line symbols. These factors may be designated "linear terrain factors." Fortunately, in most analytical processes the two kinds of distributions tend to result in different kinds of effects on military activities, and thus there is no particular reason to attempt to combine the two on the same maps.

17. The 24 factor maps specified as necessary for the seven MGI products were mapped for the entire study area. Small segments of those maps are illustrated in figs. 10-33. Of these, figs. 10-27 incorporate all of the areal terrain factors, and figs. 28-33 incorporate all linear factors.

18. Factor complex map compilation. After all of the individual factor maps have been completed, the array needed as input values for any one MGI product is selected and "stacked" to produce a factor complex map. For example, from the matrix of MGI prototype products versus factors presented in fig. 8, we note that the "Concealment" MGI product will need nine factors in the factor complex map: height of surface microgeometry feature, spacing of surface microgeometry feature, height of tallest plants, number of stems of tallest plants (per 1000 m^2), stem diameters of tallest plants, horizontal obscuration, vertical obscuration, bank height of hydrologic geometry feature, and bank angle of hydrologic geometry feature. The process of "stacking" is illustrated in detail in fig. 34.

19. The legends for the factor complex maps may become quite complex. In effect, each map added to the "stack" adds at least one digit to the code describing the factor array in each patch. For example, let it be assumed that Factor A in fig. 34 represents "height of surface microgeometry feature" and Factor B represents "spacing of

surface microgeometry feature." The two-digit code in the patches of the factor complex map (Factors A + B, fig. 34) then represents the specific combination of factor values of the two factors in each patch. That is, the patch identified by a "11" code is characterized by surface microgeometry features 0-30 cm high and spaced at distances of less than 2 m apart. A complete legend is illustrated in fig. 34. It should be noted that the four simple units on the individual factor maps have proliferated into 13 map units on the factor complex map. It can readily be seen that the legend for a factor complex map that incorporates many factor maps may become very complex indeed, since the patch codes will contain at least as many digits as there are factors in the compilation. For example, the areal terrain factor complex map compiled for use with the "cross-country speed of vehicles" model will have a 10-digit code representing each patch, while that for the "helicopter landing zone construction effort" model will have 13.

20. Such arrays of numbers are far too long to be convenient as patch identifiers on the factor complex maps, so the usual technique is to simplify the identification code used on the factor complex maps. The process is illustrated in fig. 35. The identification codes are ranked in numerical order, and a "map unit" number is assigned to each in rigorous numerical sequence. These numbers are then placed in the appropriate patches on the factor complex maps. This procedure has the obvious disadvantage of making legend utilization somewhat more difficult: the user identifies the map unit, uses that number to identify the factor complex identification code, and then uses the digits in that code to establish the relevant factor value classes.

21. Examples of the various factor complex maps produced for this study are presented in figs. 36-44. On the map legends, the columns headed "Complex" contain the factor complex identification code. In every case, the order in which the factor codes are placed in the identification code is the same as the order of listing in fig. 8.

22. Performance prediction maps. Each "patch" (i.e. each delineated area) on the factor complex map represents an area that is essentially homogeneous with respect to the factors included in the

compilation. Thus, the factor values represented by the class codes on one patch on the map can be accepted as input values to the relevant performance prediction model, and one calculation will result in a value that represents the performance prediction for that entire patch. The general procedure is then to calculate the performance prediction for each patch, and then group the resulting values into convenient classes for the final MGI product map. In the normal course of events, some adjacent patches will exhibit closely similar performance values, and thus may fall into the same performance class. In this event, the boundaries between the similar patches are removed from the final MGI product map. The resultant MGI product map (or performance prediction map) may then resemble the example illustrated in fig. 45. In the example, the "model" used to make a "performance prediction" is only a simple algebraic relation, and is for illustrative purposes only.

23. Examples of portions of the performance prediction maps produced for this study are presented in figs. 46-52.

Conclusions and Recommendations

Conclusions

24. The concept and techniques in this study appear to comprise an expedient and economical method of producing quantitatively based MGI products for the field commander. In addition, the procedure seems to be far more objective than previous methods, thus making MGI products produced by different teams of analysts more uniform and less subject to individual bias or preconception.

Recommendations

25. In order to reduce the time required to compile the various MGI products, and to improve the reliability and objectivity of the final products, it is recommended that:

a. Research be organized to develop the various mathematical performance prediction models that will be required to handle the full spectrum of terrain intelligence needs.

b. Effort be devoted to the automation of many of the processes that must now be done manually. Of specific importance is the process of compiling the factor complex maps from the factor maps; this process is presently very time consuming and therefore costly, but it is entirely rigorous and could accordingly be accomplished by computer processing.

Table 1

Summary of Terrain Factor Classes Used in Constructing Terrain Factor Complex Maps

Substrate characteristics

Soil type:

- 50% stones or rock fragments
- Gravel
- Sand
- Silt
- Clay

Moisture content, cm water/cm soil:

- 0.0 to 0.1
- 0.1 to 0.3
- 0.3 to 0.8
- 0.8 to 1.0

Surface strength, RCI:

- 0 to 20
- 20 to 30
- 30 to 60
- >60

Slope of soil strength profile, deg:

- 0 to 10
- 10 to 30
- 30 to 60
- 60 to 120
- >120

Unconfined compressive strength, psi:*

- <300
- >300

Soil thickness, m:

- No soil
- <0.2
- 0.2 to 1.0
- 1.0 to 5.0
- >5.0

Depth to water table, m:

- 0.0 to 0.5
- 0.5 to 1.5
- 1.5 to 4.0
- >4.0

Surface macrogeometry

Slope, deg:

- 0 to 2
- 2 to 10
- 10 to 30
- 30 to 90

Elevation, m:

- 0 to 10
- 10 to 500
- 500 to 1000
- >1000

Surface microgeometry

Height of feature, cm:

- 0 to 30
- 30 to 50
- 50 to 70
- >70

Approach angle of feature, deg:

- 0 to 5
- 5 to 10
- 10 to 20
- 20 to 30
- 30 to 90

Spacing of feature, m:

- 0 to 2
- 2 to 4
- 4 to 10
- >10

Vegetation structure

Height of tallest plants, m:

- 0.0 to 0.5
- 0.5 to 3.0
- 3.0 to 8.0
- 8.0 to 14.0
- 14.0 to 24.0
- >24.0

(Continued)

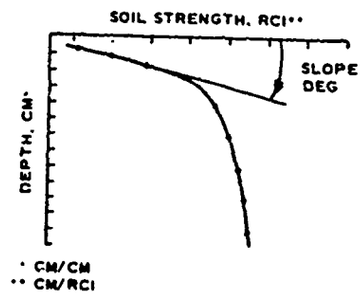
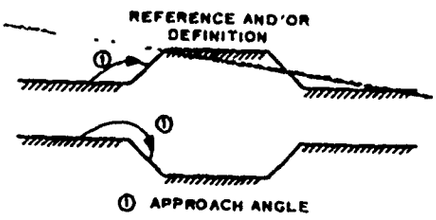
* A table of factors for converting British units of measurement to metric units is presented on page vii.

Table 1 (Concluded)

Vegetation structure (continued)	Hydrologic geometry
Number of stems of tallest plants per 1000 m^2:	Bank height, m:
>900	0 to 1
500 to 900	1 to 2
100 to 500	2 to 3
10 to 100	3 to 5
2 to 10	>5
0 to 2	
Stem diameter of tallest plants, cm:	Bank angle, deg:
0 to 2	0 to 10
2 to 7	10 to 20
7 to 15	20 to 45
15 to 30	45 to 90
30 to 60	
>60	Water width, m:
Specific gravity of green wood:	No water
0.0 to 0.20	0 to 9
0.20 to 0.40	9 to 15
0.40 to 0.60	15 to 21
0.60 to 0.80	21 to 30
>0.80	>30
Horizontal obscuration, m:	Gap width, m:
0 to 5	0 to 9
5 to 10	9 to 15
10 to 20	15 to 21
20 to 50	21 to 30
>50	30 to 50
	>50
Vertical obscuration, % covered:	Water depth, cm:
0 to 10	No water
10 to 30	01 to 100
30 to 60	100 to 300
60 to 100	>300
	Water current velocity, mps:
	No water
	0 to 1
	1 to 2
	2 to 3
	>3

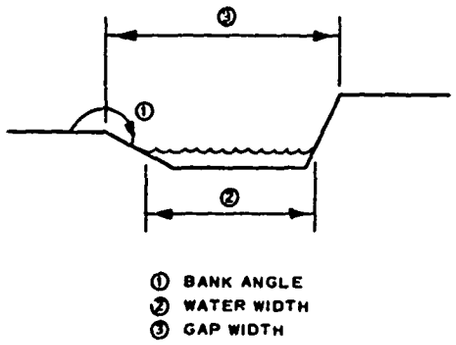
Table 2

References and/or Definitions for Origin of Selected Factor Classes Found in Table 1

Factor	Class	Reference and/or Definition
Soil type	50% stones or rock fragments	GW, GP — From Unified Soil Classification System
	Gravel	GM, GC — From Unified Soil Classification System
	Sand	SM, SC — From Unified Soil Classification System
	Silt	ML, CL — From Unified Soil Classification System
	Clay	MH, CH — From Unified Soil Classification System
Surface strength	0 to 20 RCI	J. G. Kennedy and E. S. Rush, "Trafficability of Soils; Development of Revised Mobility Index Formula for Self-Propelled Wheeled Vehicles in Fine-Grained Soils," Technical Memorandum No. 3-240, 18th Supplement, Mar 1968, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
	20 to 30 RCI	
	30 to 60 RCI	
	>60 RCI	
Slope of soil strength profile	0 to 10 deg	
	10 to 30 deg	
	30 to 60 deg	
	60 to 120 deg	
	>120 deg	
Approach angle of feature	0 to 5 deg	
	5 to 10 deg	
	10 to 20 deg	
	20 to 30 deg	
	30 to 90 deg	
Horizontal obscuration	0 to 5 m	Defined as the distance at which an object of a given size is totally obscured. For this study the objects considered were a man and a jeep. "Visibility Studies I, Instrument and Concepts Development" (in preparation), U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
	5 to 10 m	
	10 to 20 m	
	20 to 50 m	
	>50 m	

(Continued)

Table 2 (Concluded)

Factor	Class	Reference and/or Definition
Vertical obscuration	0 to 10% covered 10 to 30% covered 30 to 60% covered 60 to 100% covered	Defined as the proportion of a given area that is encompassed when the crowns of all plants are projected vertically downward to the ground. H. T. Odum and R. F. Pigeon, ed., "Tropical Rain Forest; A Study of Irradiation and Ecology at El Verde, Puerto Rico," 1970, Division of Technical Information Extension, U. S. Atomic Energy Commission, Oak Ridge, Tenn.
Bank angle	0 to 10 deg 10 to 20 deg 20 to 45 deg 45 to 90 deg	See below
Water width	No water 0 to 9 m 9 to 15 m 15 to 21 m 21 to 30 m >30 m	
Gap width	0 to 9 m 9 to 15 m 15 to 21 m 21 to 30 m 30 to 50 m >50 m	See above

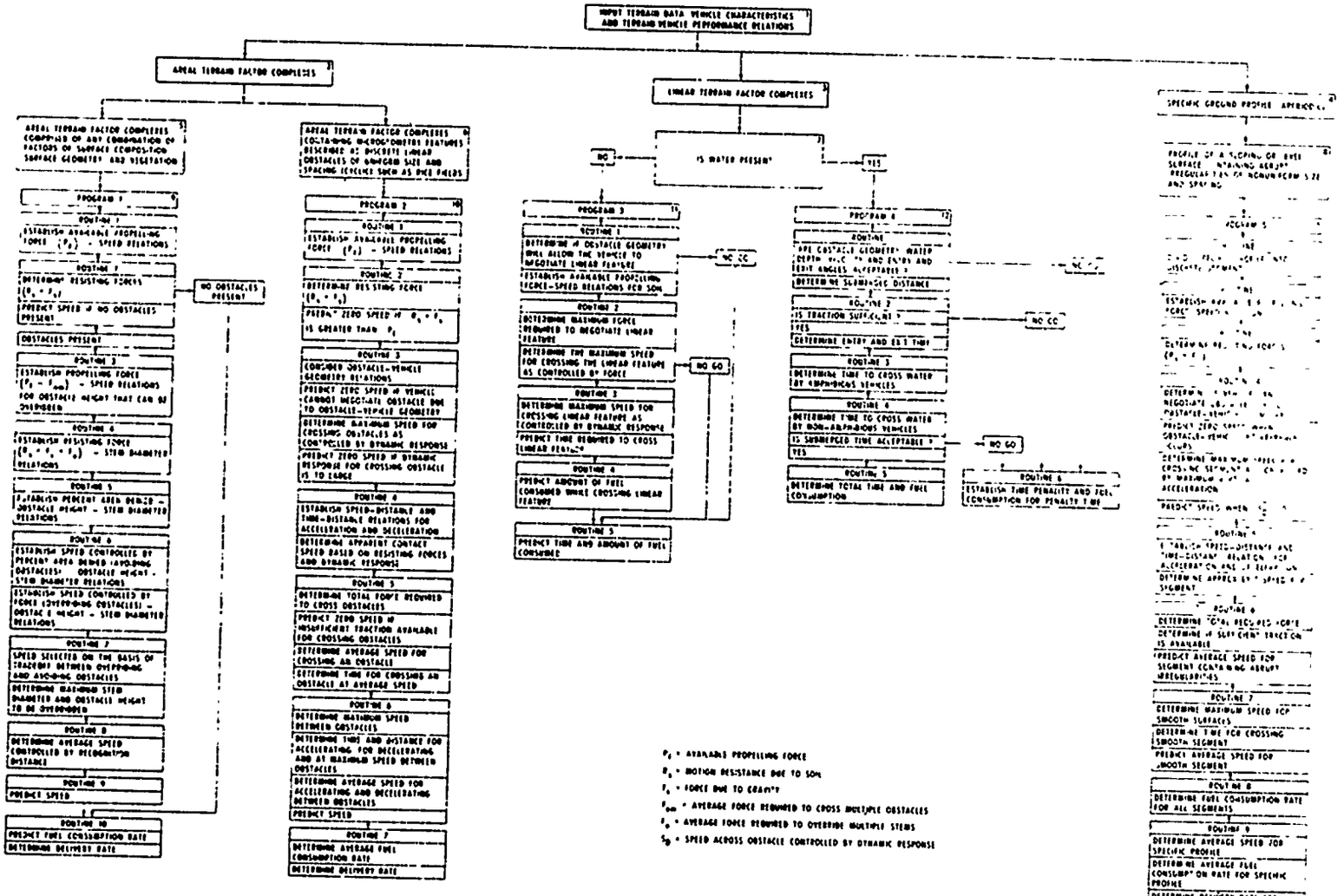


Fig. 1. WES analytical model for predicting vehicle performance

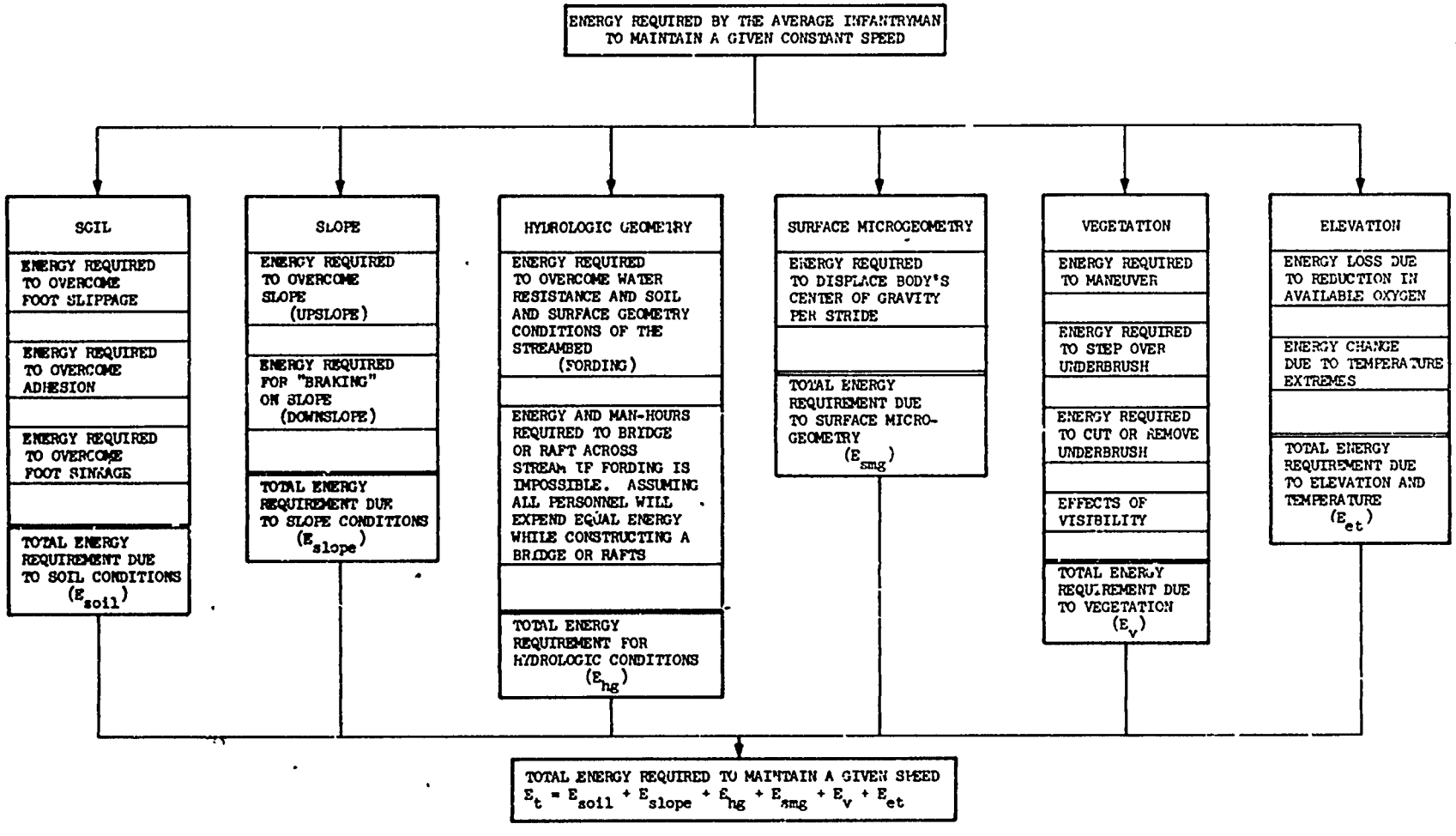


Fig. 2. HLZ construction effort

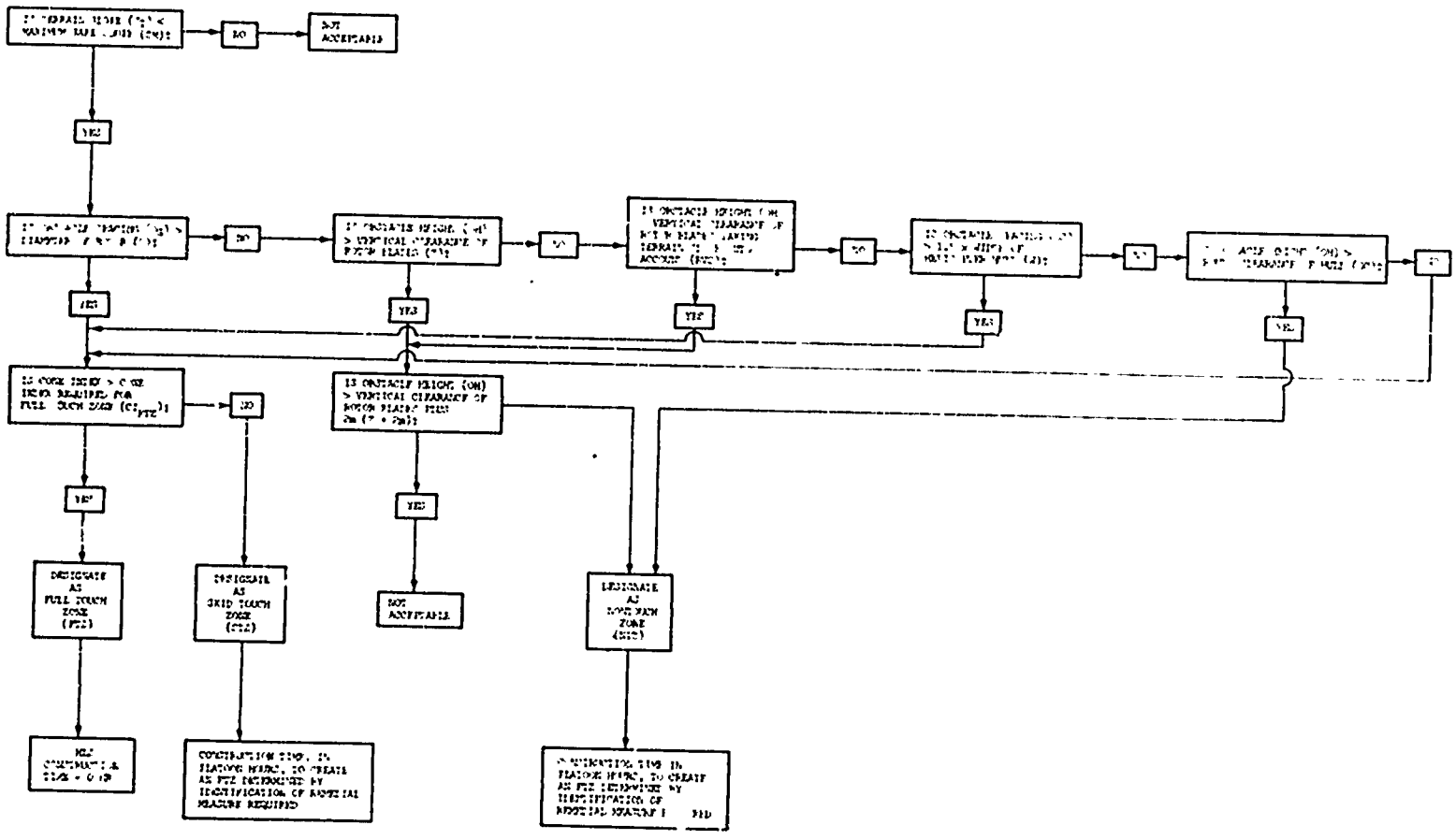


Fig. 3. Airfield construction effort model

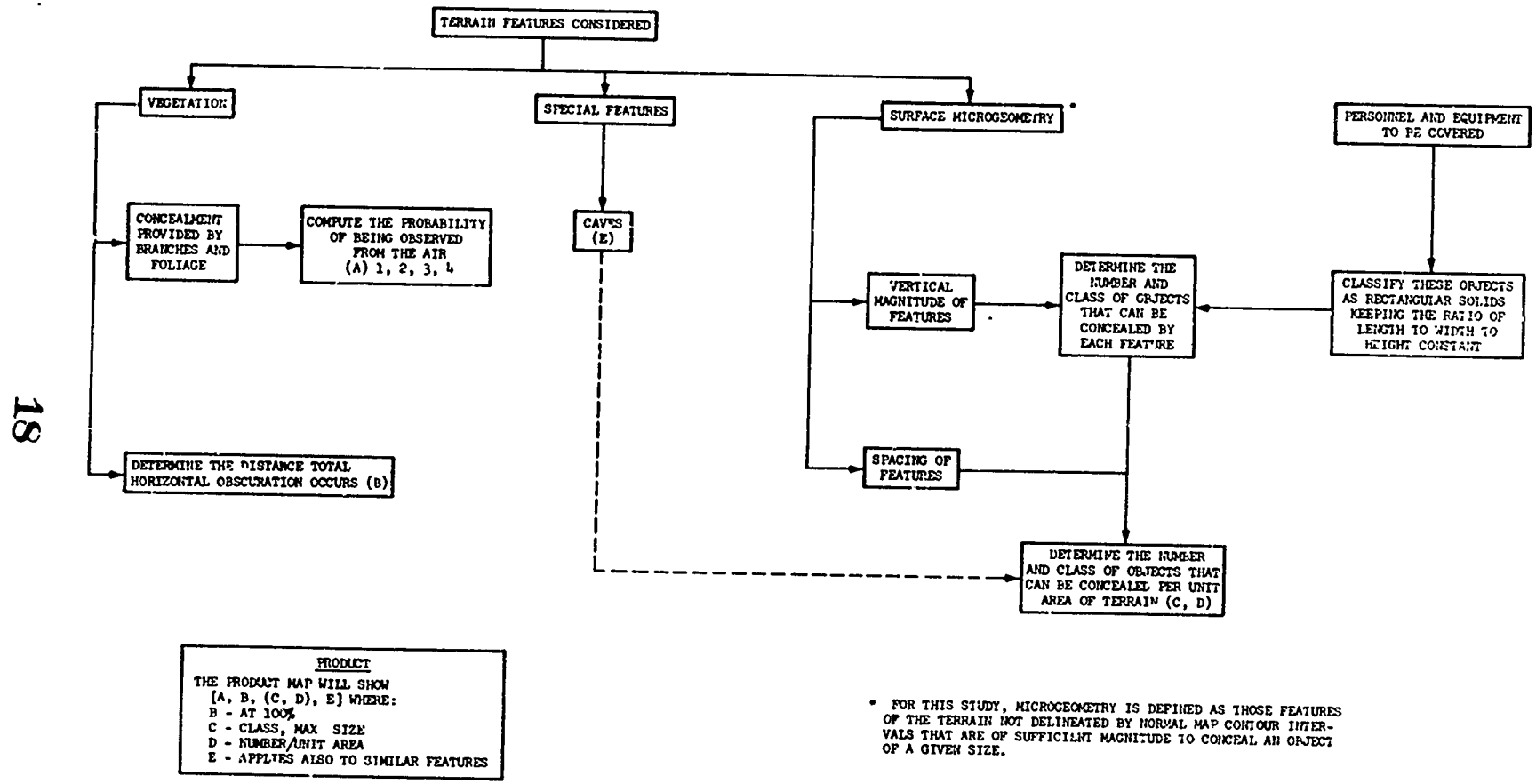


Fig. 4. An analytical model for determining cross-country speed for personnel

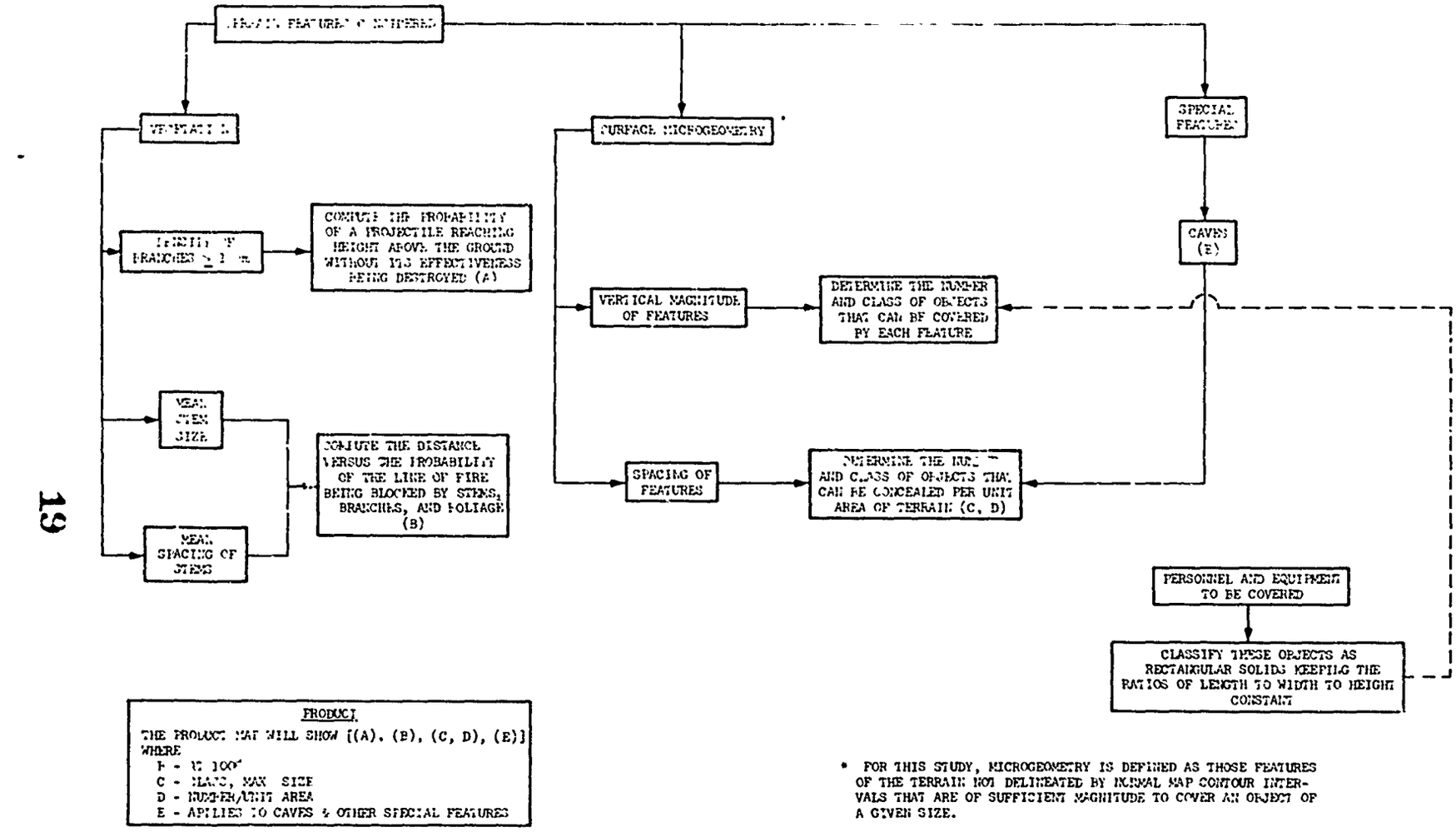


Fig. 5. An analytical model for determining concealment offered by naturally occurring terrain features

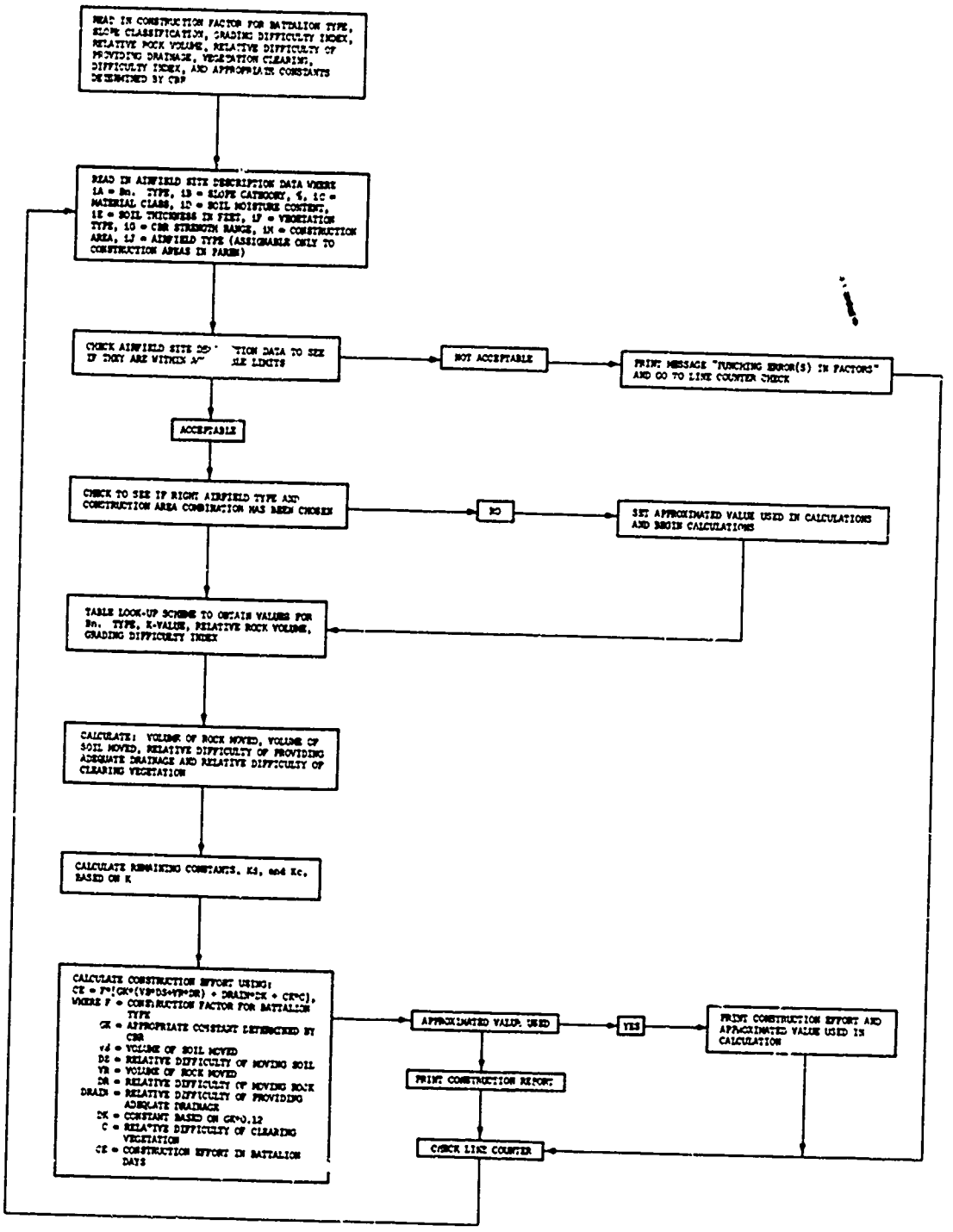


Fig. 6. An analytical method for determining cover offered by naturally occurring terrain features

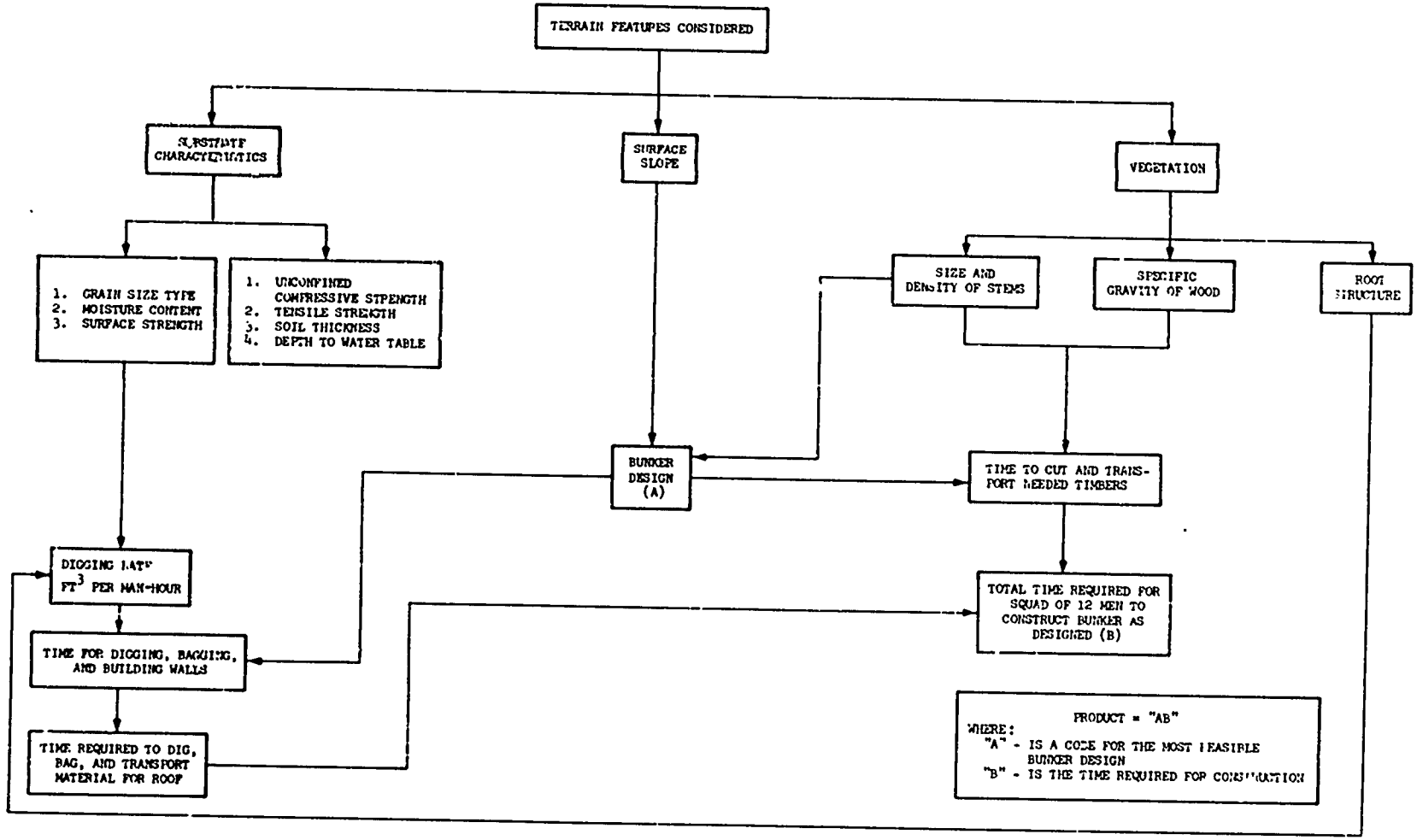


Fig. 7. Analysis of requirements for bunker construction effort relative to pertinent terrain features

PROTOTYPE MG1 PRODUCTS AND MODELS*

FACTORS	CROSS-COUNTRY SPEED FOR VEHICLES	CROSS-COUNTRY SPEED FOR PERSONNEL	HLZ CONSTRUCTION EFFORT	CONCEALMENT CHARACTERISTICS	COVER CHARACTERISTICS	AIRFIELD CONSTRUCTION EFFORT	BUNKER CONSTRUCTION EFFORT
SUBSTRATE CHARACTERISTICS							
SOIL TYPE			X		X	X	X
MOISTURE CONTENT			X			X	X
SURFACE STRENGTH	X	X			X	X	X
SLOPE OF SOIL STRENGTH PROFILE	X				X		
UNCONFINED COMPRESSIVE STRENGTH			X			X	X
SOIL THICKNESS			X			X	X
DEPTH TO WATER TABLE						X	X
SURFACE MACROGEOMETRY							
SLOPE	X	X	X		X	X	X
ELEVATION		X	X				
SURFACE MICROGEOMETRY							
HEIGHT OF FEATURE	X	X	X	X	X		
APPROACH ANGLE OF FEATURE	X		X				
SPACING OF FEATURE	X	X	X	X	X		
VEGETATION STRUCTURE							
HEIGHT OF TALLEST PLANTS		X	X	X	X		
NO OF STEMS OF TALLEST PLANTS,'1000 M^2	X	X	X	X	X	X	X
STEM DIAMETER OF TALLEST PLANTS	X	X	X	X	X	X	X
SPECIFIC GRAVITY OF GREEN WOOD	X		X				X
HORIZONTAL OBSCURATION	X	X		X			
VERTICAL OBSCURATION				X			
HYDROLOGIC GEOMETRY							
BANK HEIGHT	X	X		X	X		
BANK ANGLE	X	X		X	X		
WATER WIDTH	X	X					
CAP WIDTH	X	X					
WATER DEPTH	X	X					
WATER CURRENT VELOCITY	X	X					

* THE MODEL IS THE ANALYTICAL PROCESS BY WHICH THE IDENTIFIED FACTORS ARE CONSIDERED, THE RESULT BEING A PRODUCT OF THE SAME NAME.

Fig. 8. Matrix of interrelations among MGI products and factors

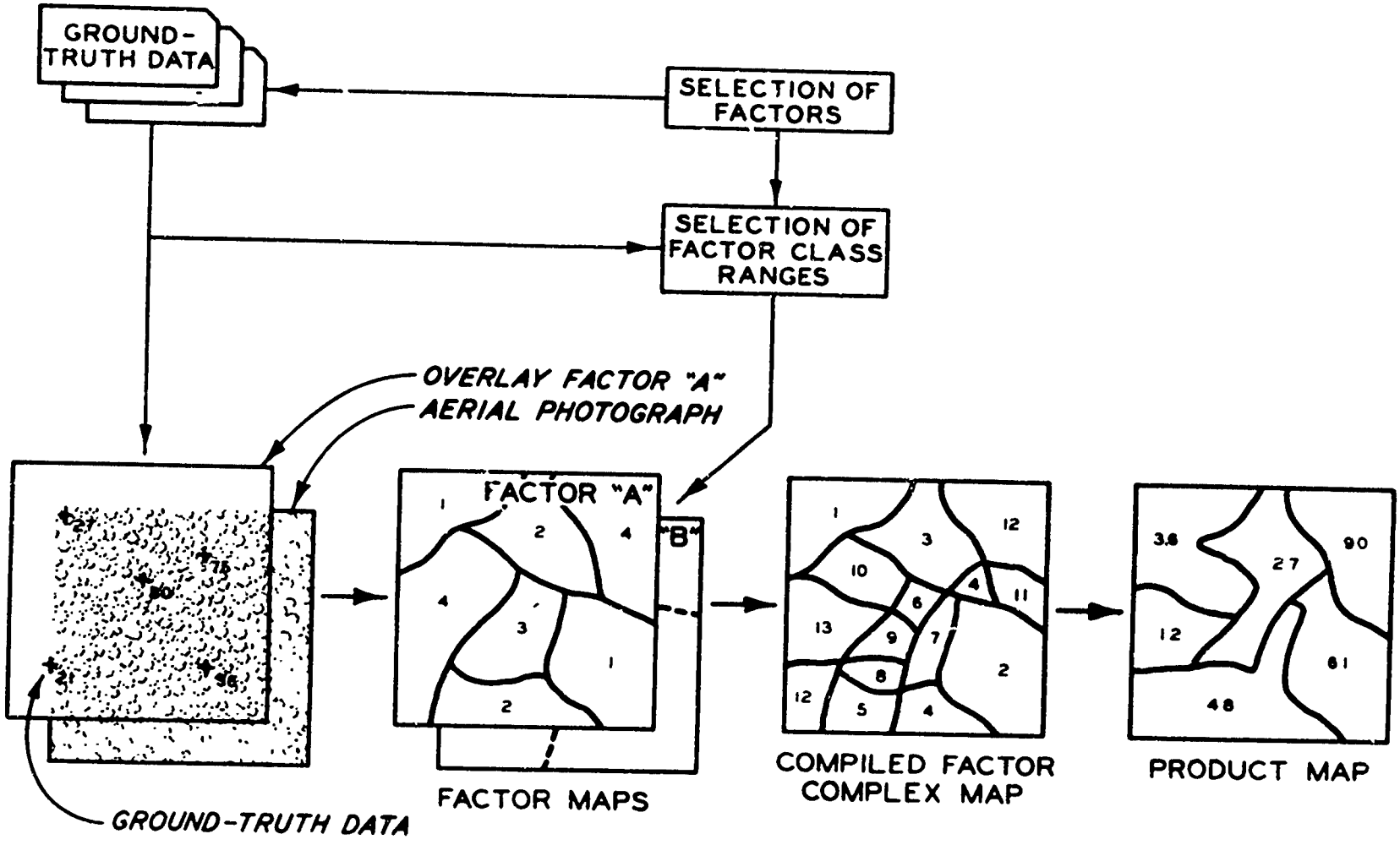


Fig. 9. Sequence of stages in the construction of MGI product map

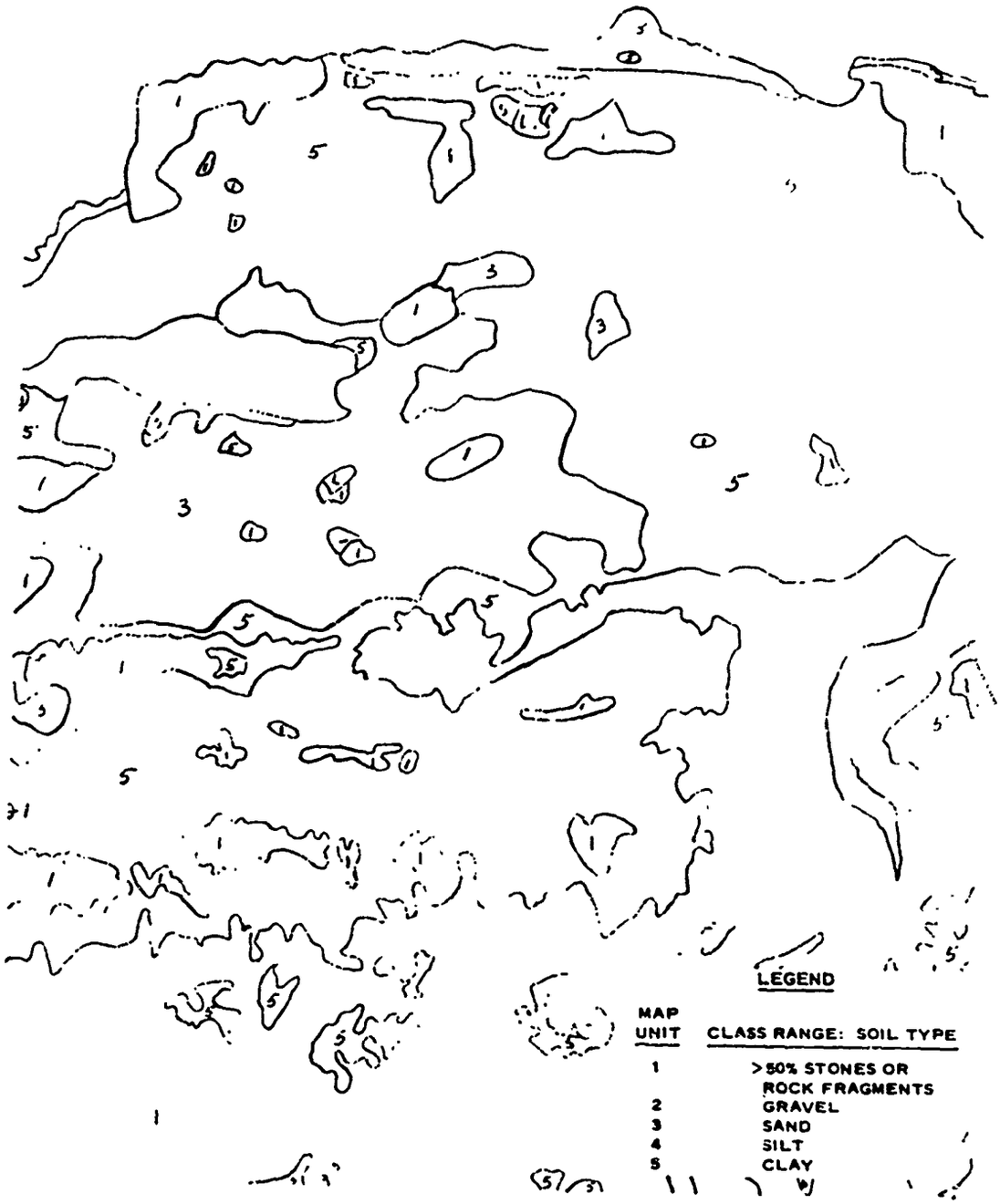


Fig. 10. Factor map. Substrate characteristics: Soil type

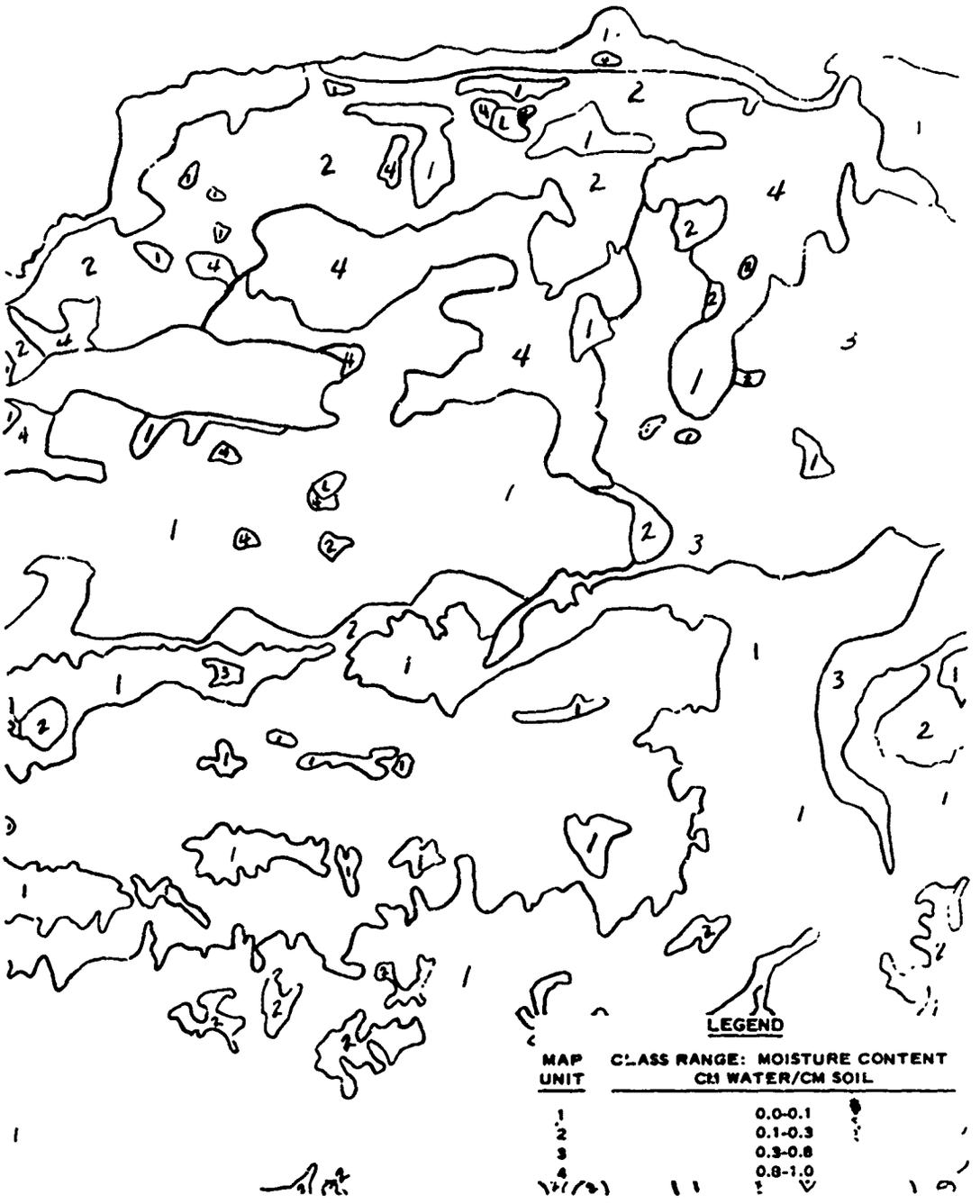


Fig. 11. Factor map. Substrate characteristics: Moisture content

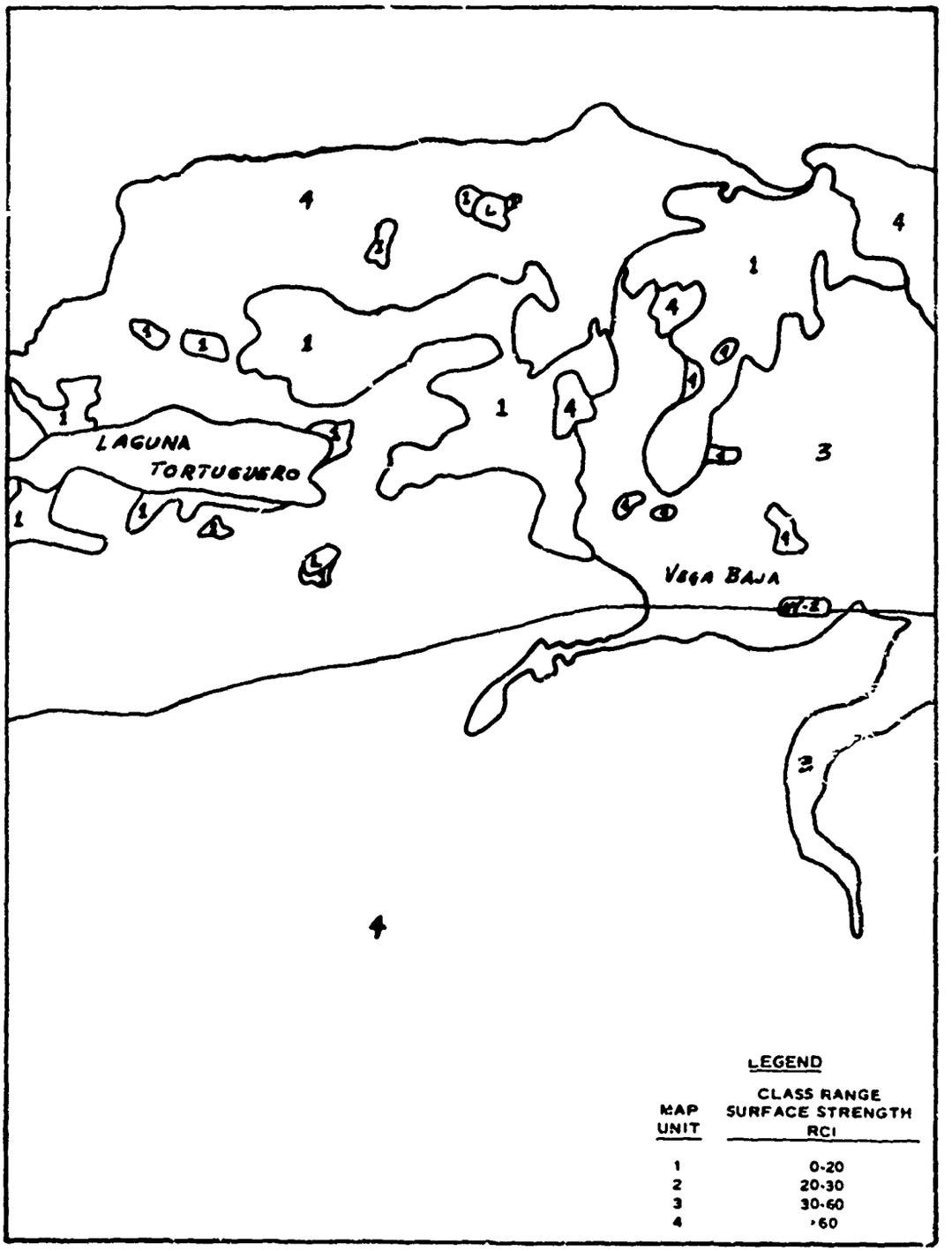


Fig. 12. Factor map. Substrate characteristics: Surface strength

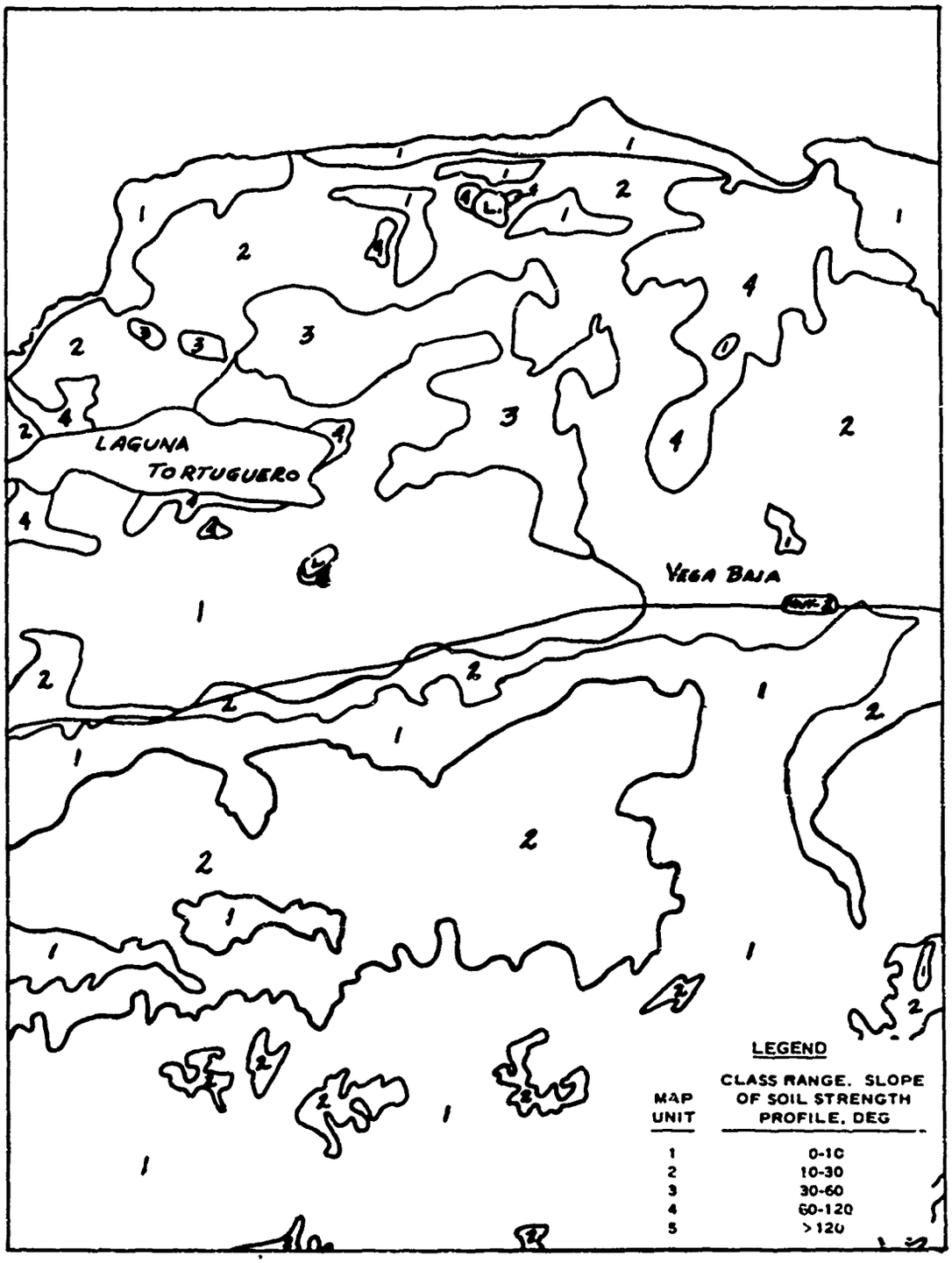


Fig. 13. Factor map. Substrate characteristics: Slope of soil strength profile

2

LEGEND

MAP UNIT	CLASS RANGE: UNCONFINED COMPRESSIVE STRENGTH, PSI
1	< 300
2	> 300

Fig. 14. Factor map. Substrate characteristics: Unconfined compressive strength

Fig. 15. Factor map. Substrate characteristics: Soil thickness

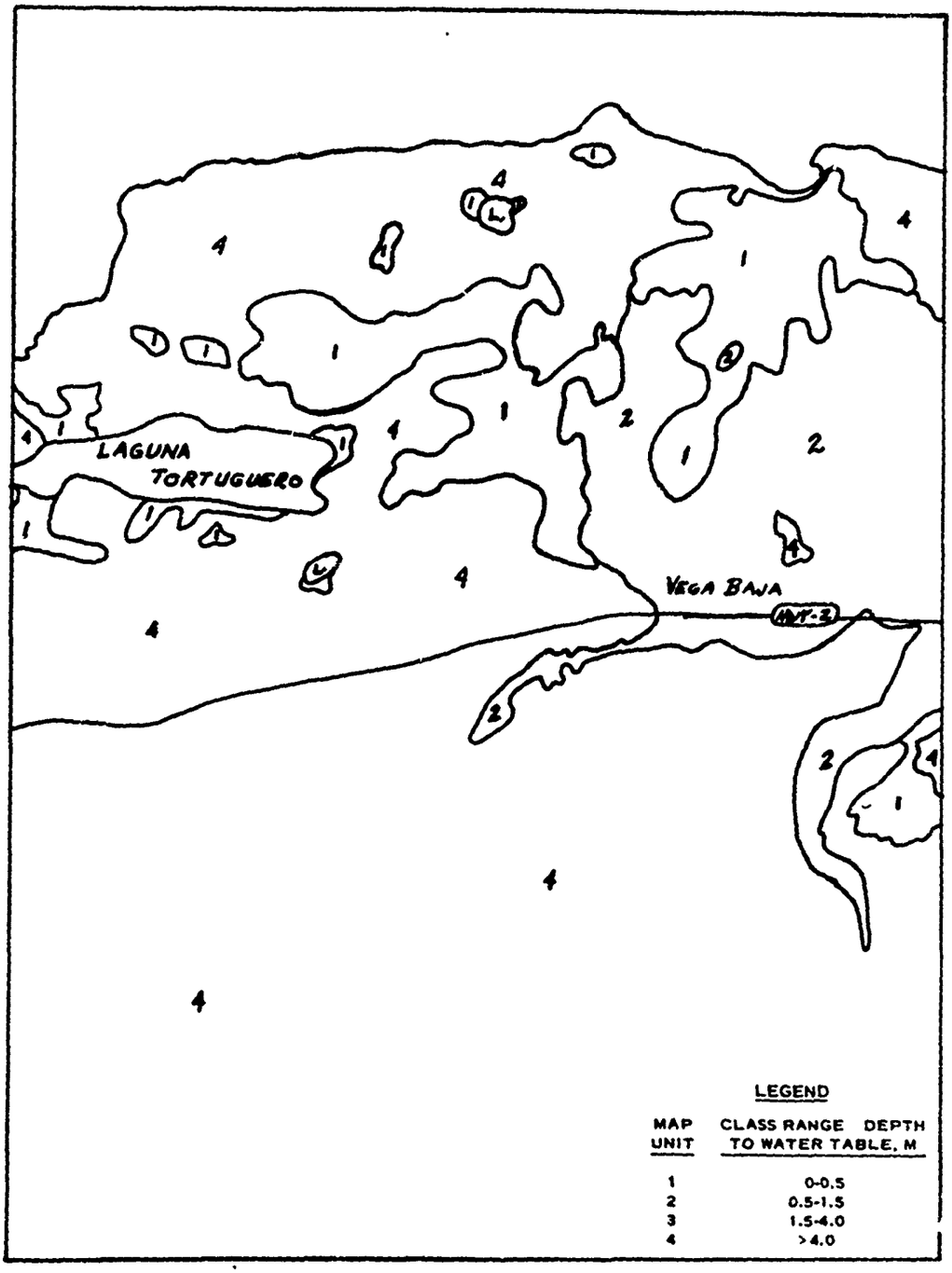


Fig. 16. Factor map. Substrate characteristics: Depth to water table

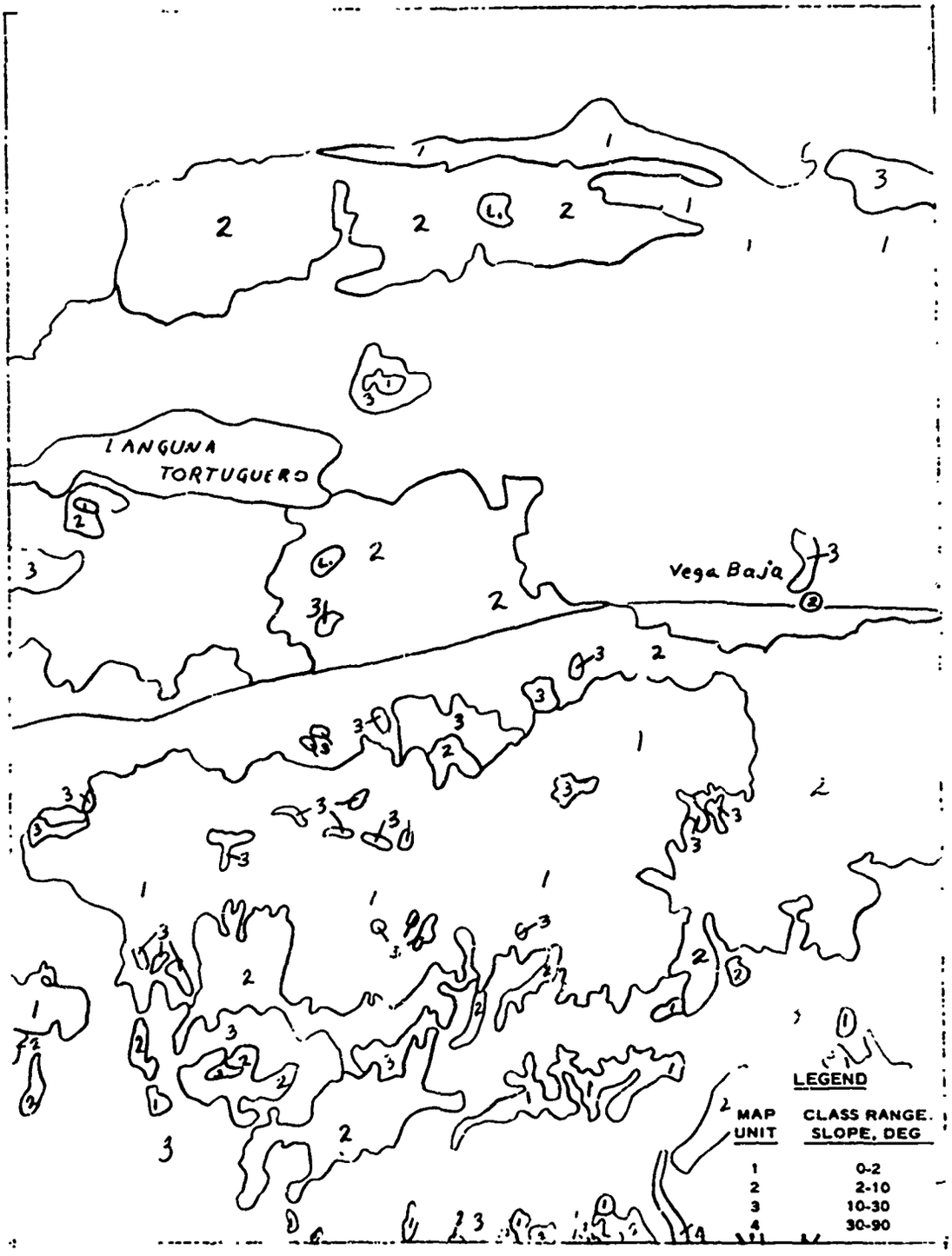


Fig. 17. Factor map. Surface macrogeometry: Slope

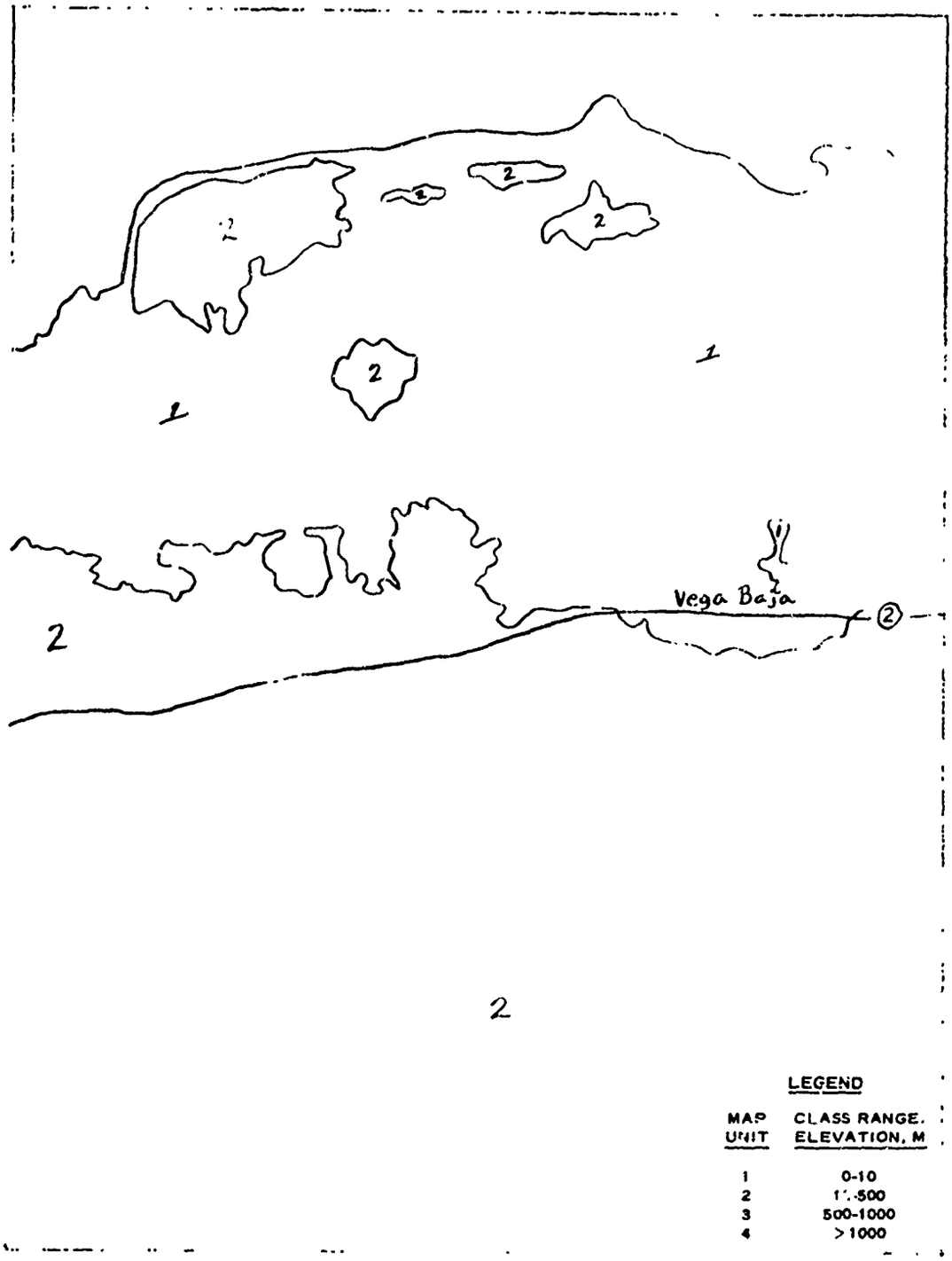
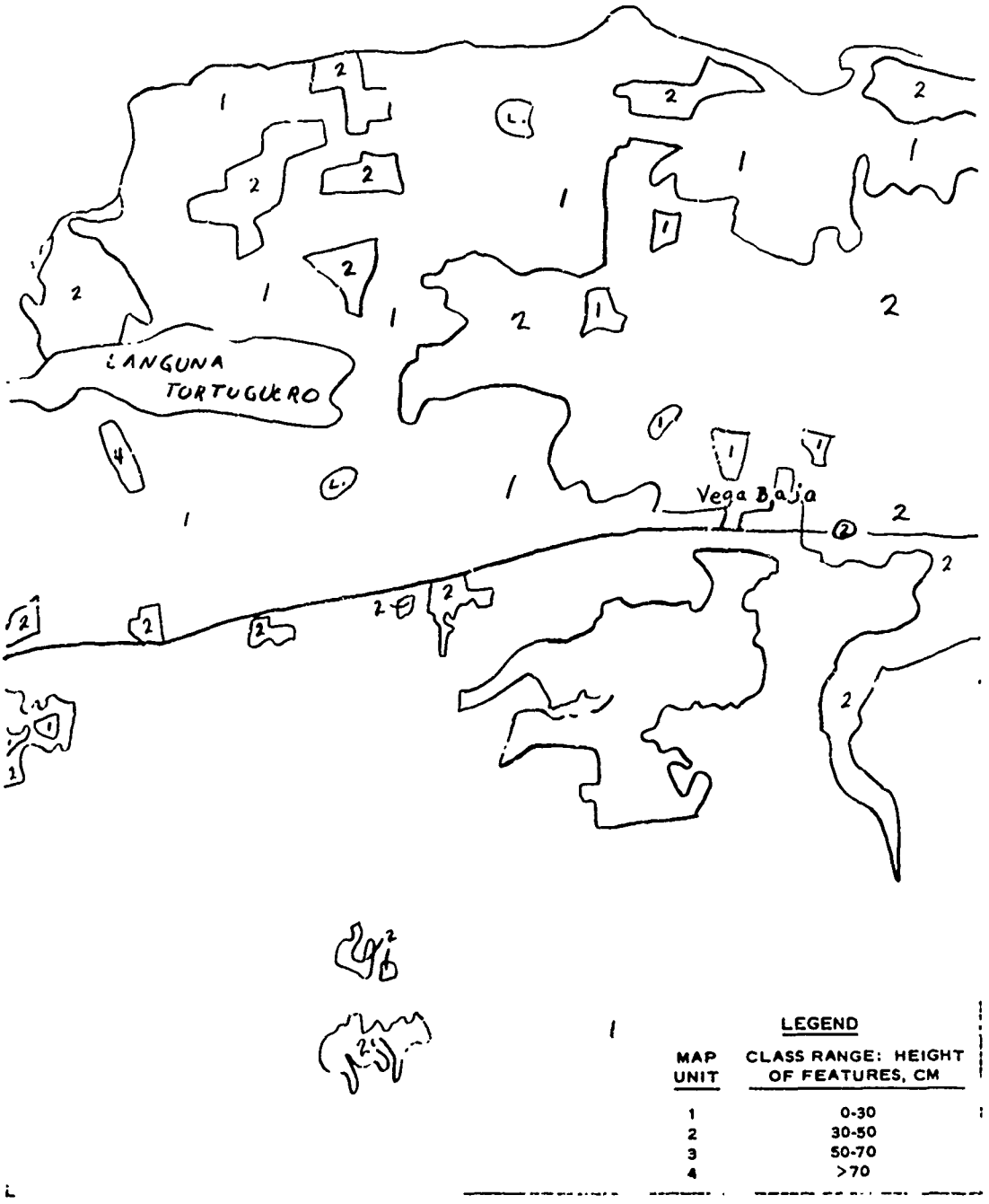


Fig. 18. Factor map. Surface macrogeometry: Elevation



LEGEND

MAP UNIT	CLASS RANGE: HEIGHT OF FEATURES, CM
1	0-30
2	30-50
3	50-70
4	>70

Fig. 19. Factor map. Surface microgeometry: Height of feature

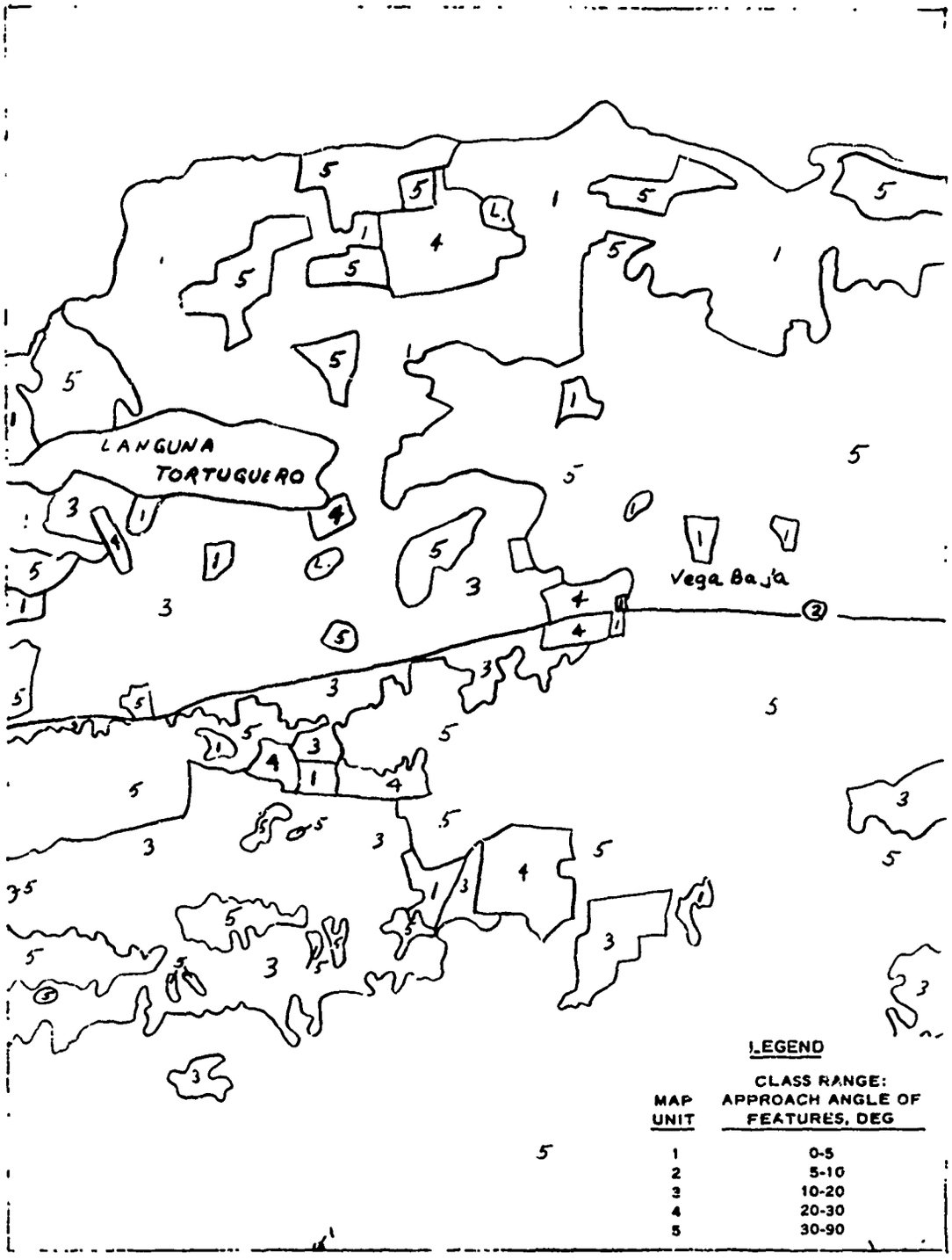


Fig. 20. Factor map. Surface microgeometry: Approach angle of feature

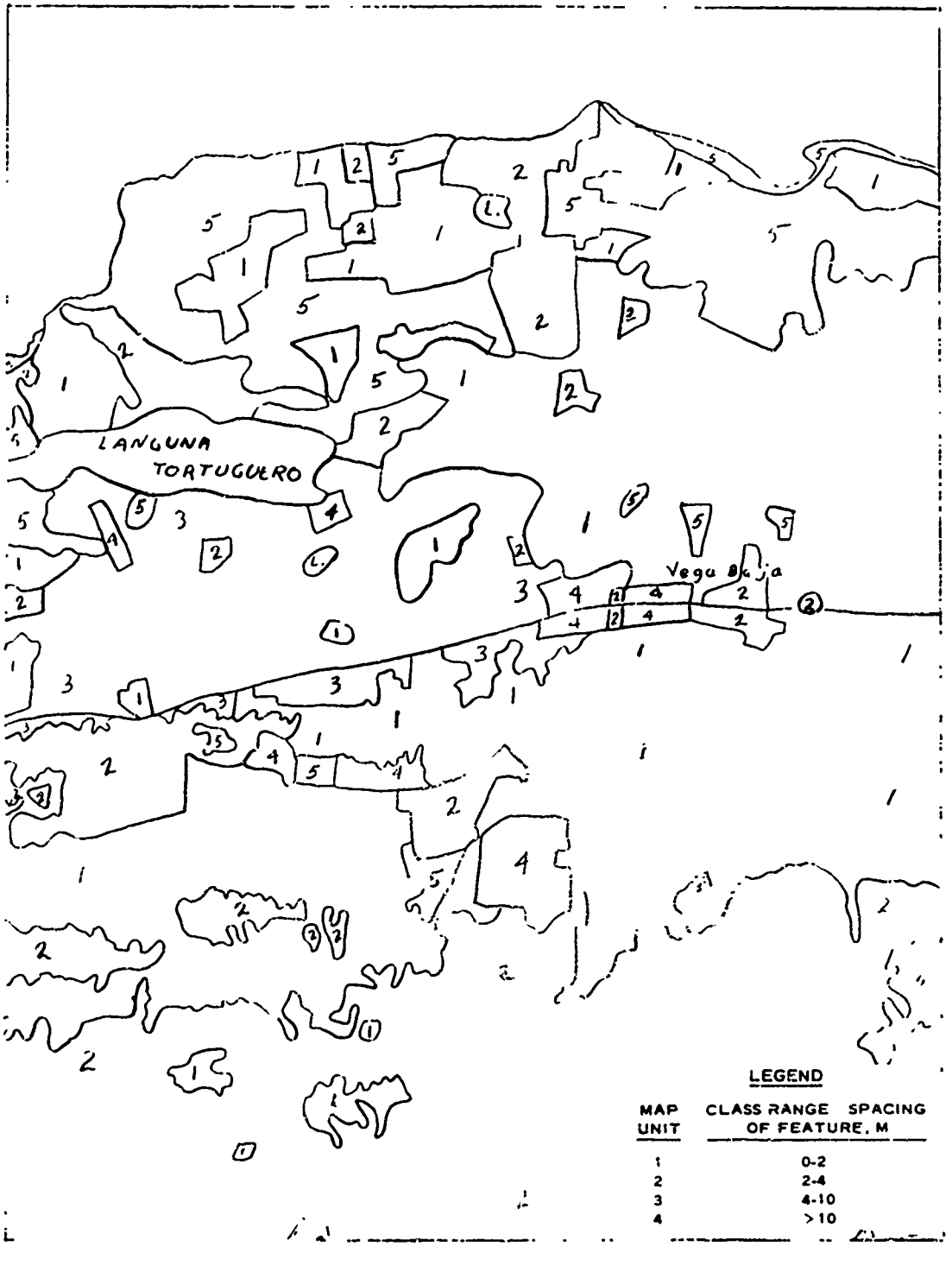


Fig. 21. Factor map. Surface microgeometry: Spacing of feature

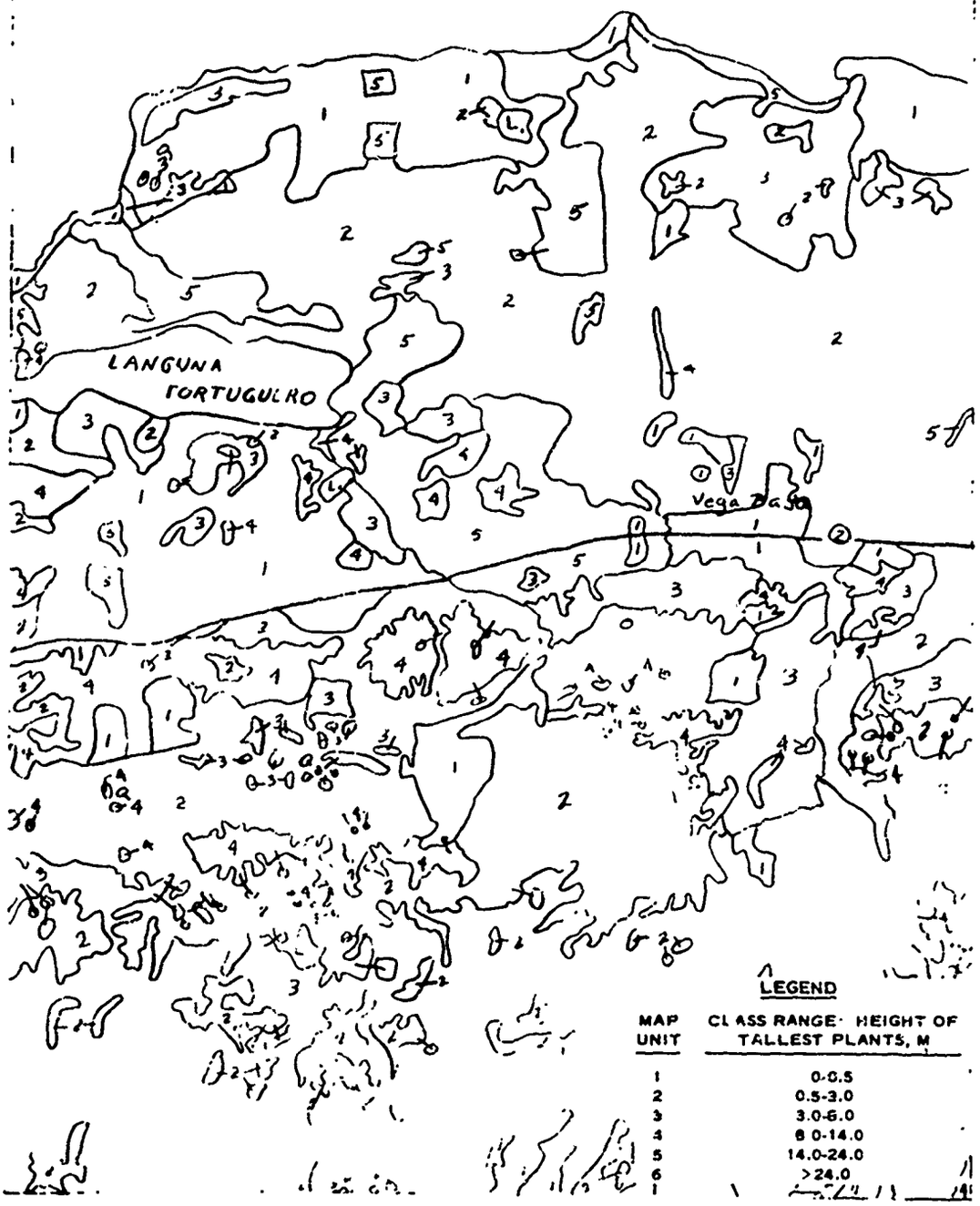


Fig. 22. Factor map. Vegetation structure: Height of tallest plants

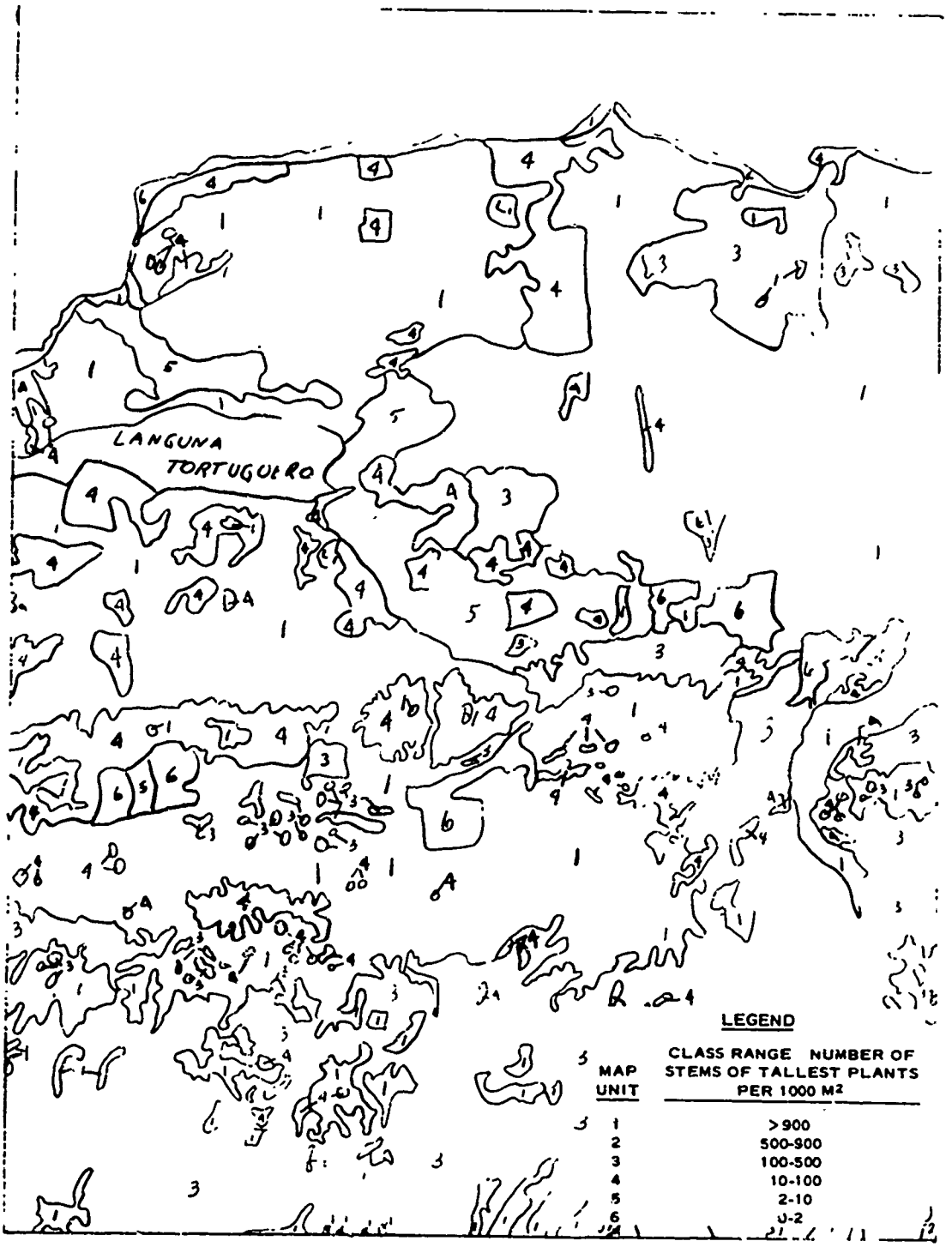


Fig. 23. Factor map. Vegetation structure: Number of stems of tallest plants per 1000 m^2

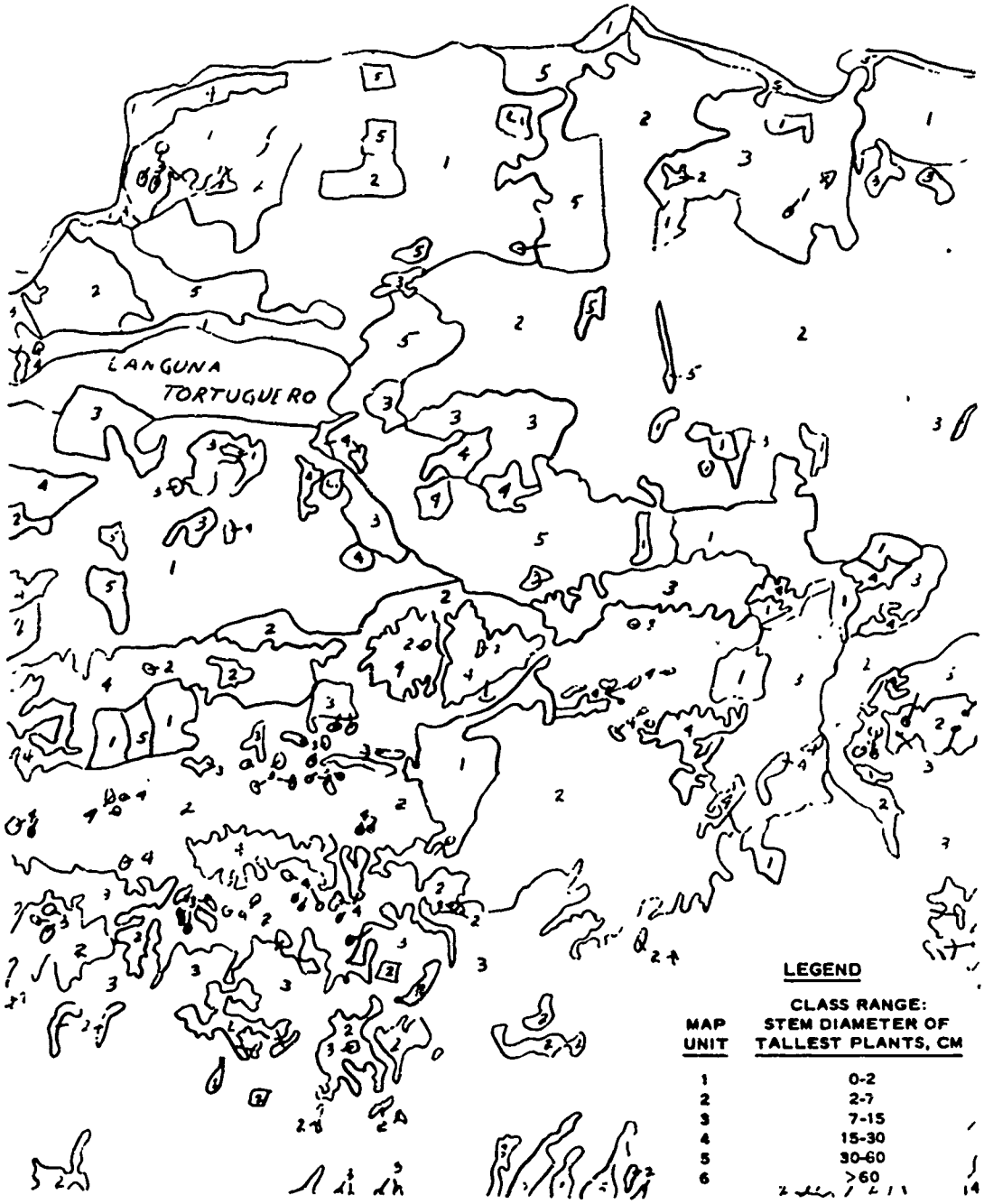


Fig. 24. Factor map. Vegetation structure: Stem diameter of tallest plants

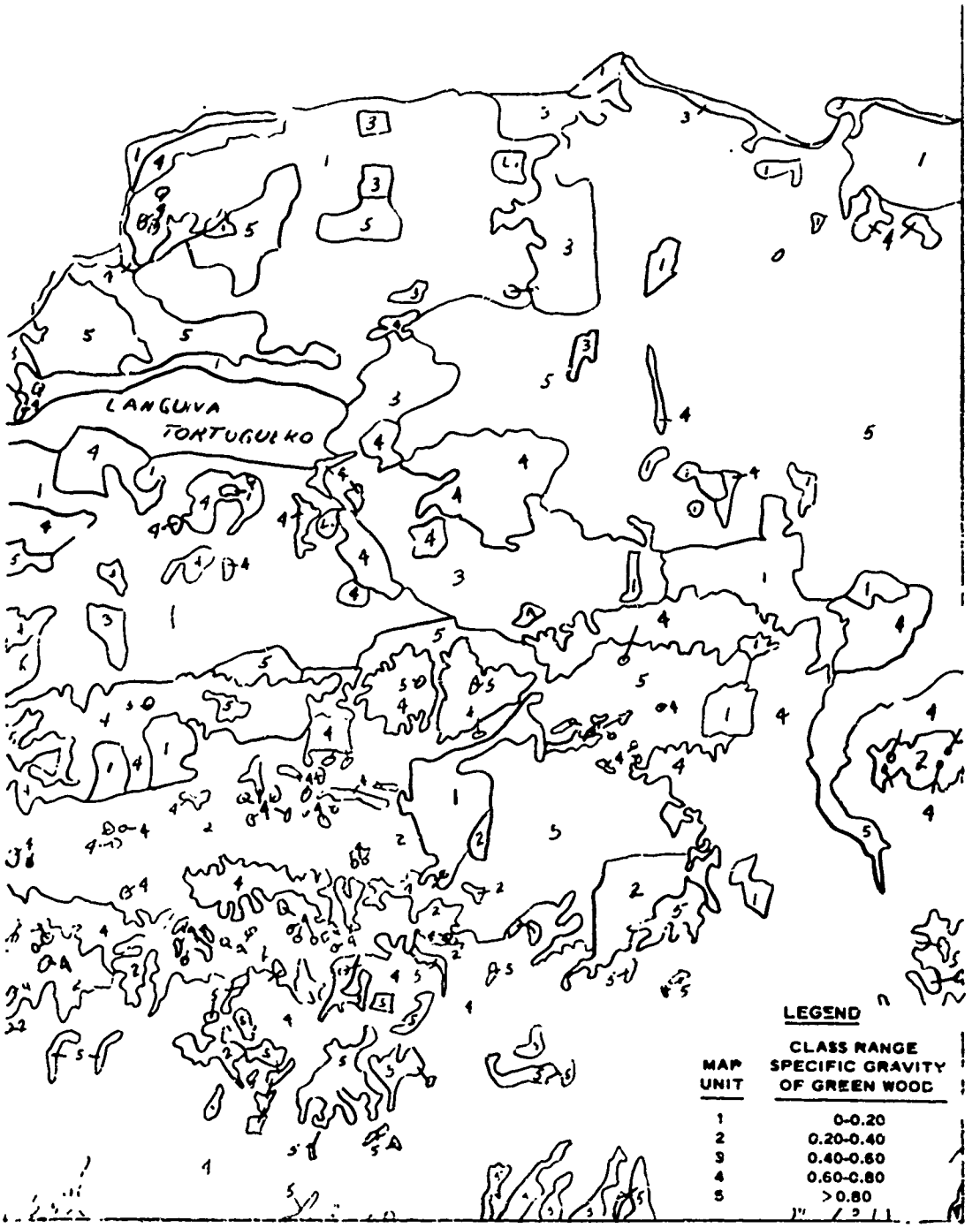


Fig. 25. Factor map. Vegetation structure: Specific gravity of green wood

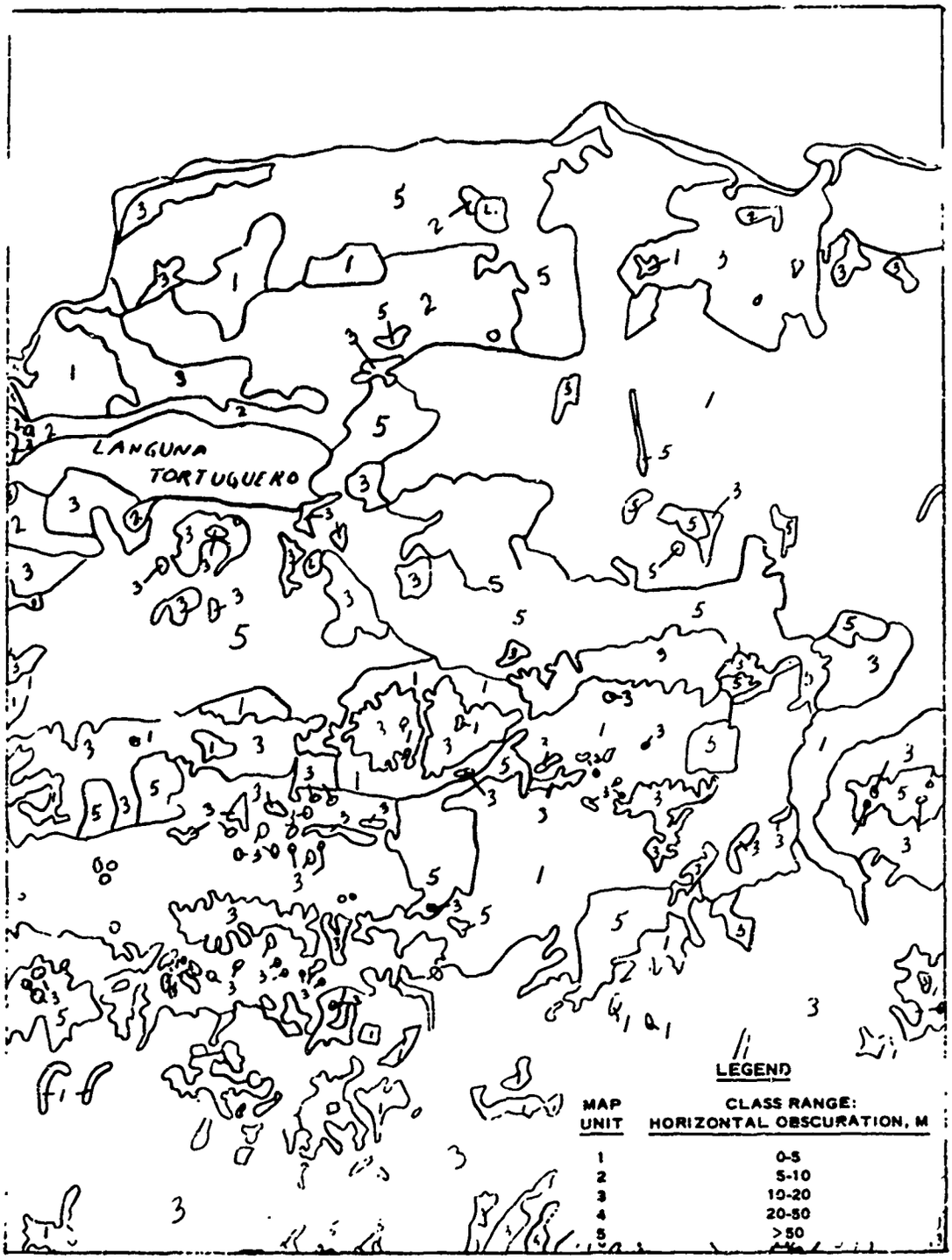


Fig. 26. Factor map. Vegetation structure: Horizontal obscuration

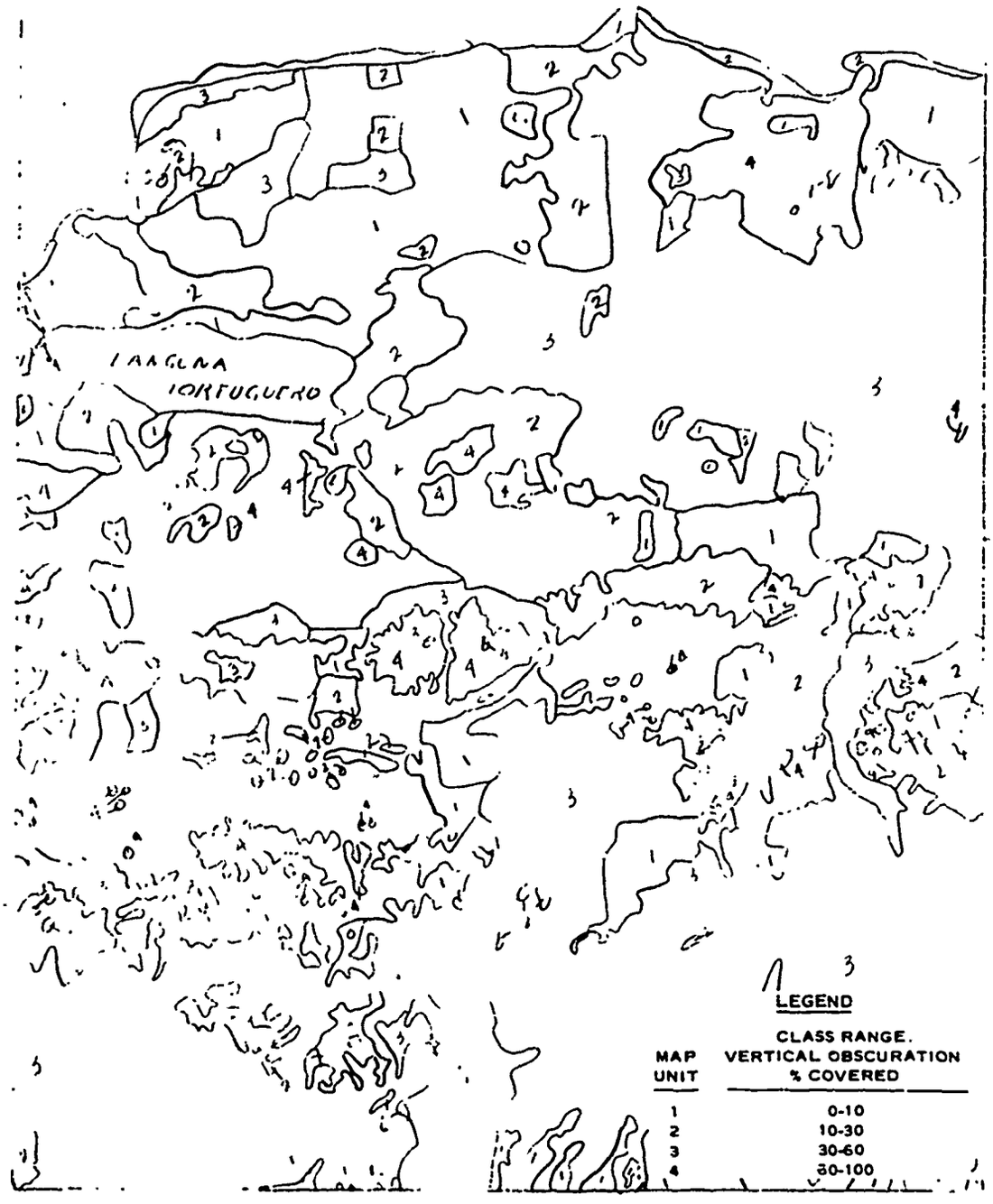


Fig. 27. Factor map. Vegetation structure: Vertical obscuration

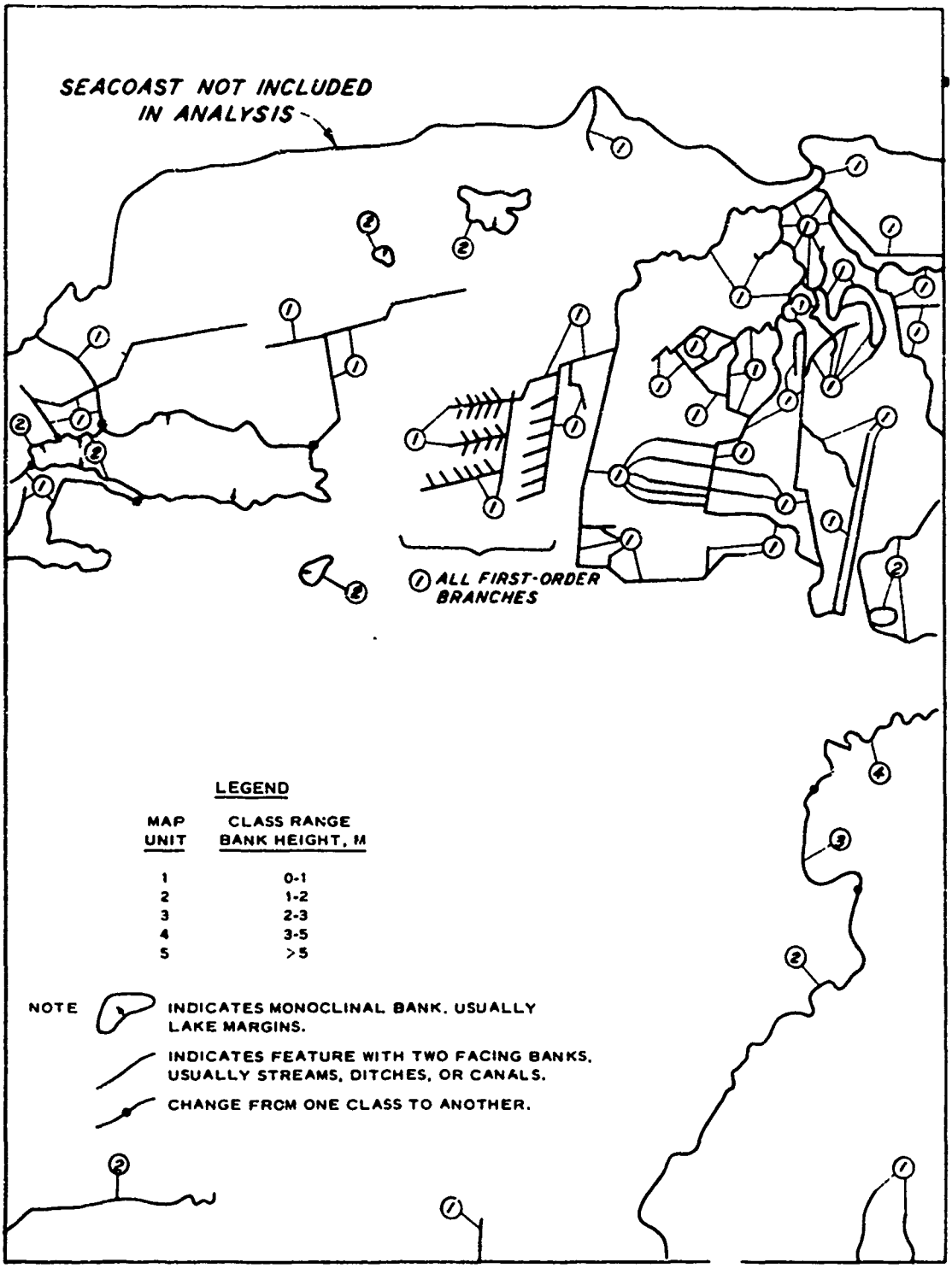


Fig. 28. Factor map. Hydrologic geometry: Bank height

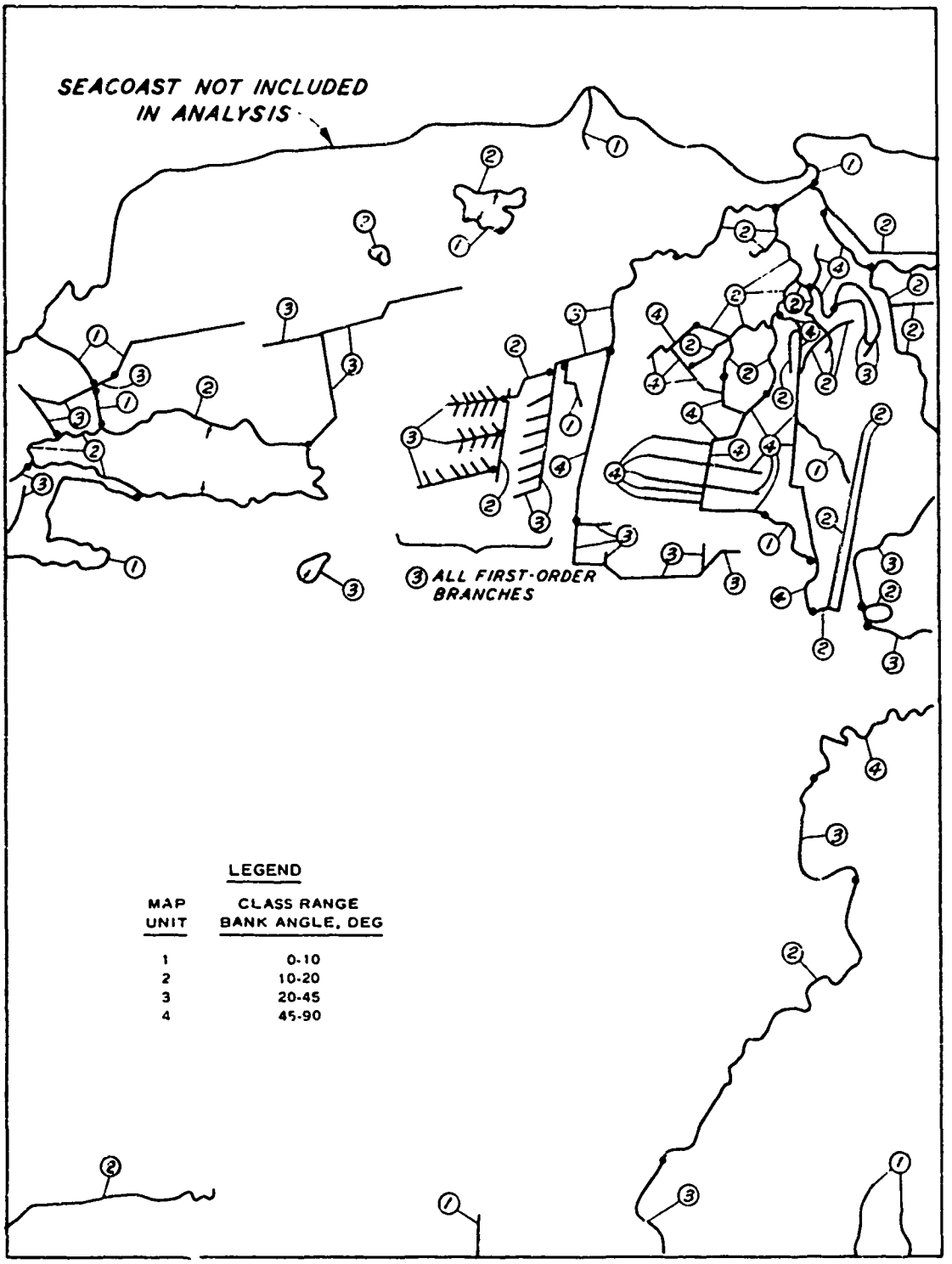


Fig. 29. Factor map. Hydrologic geometry: Bank angle

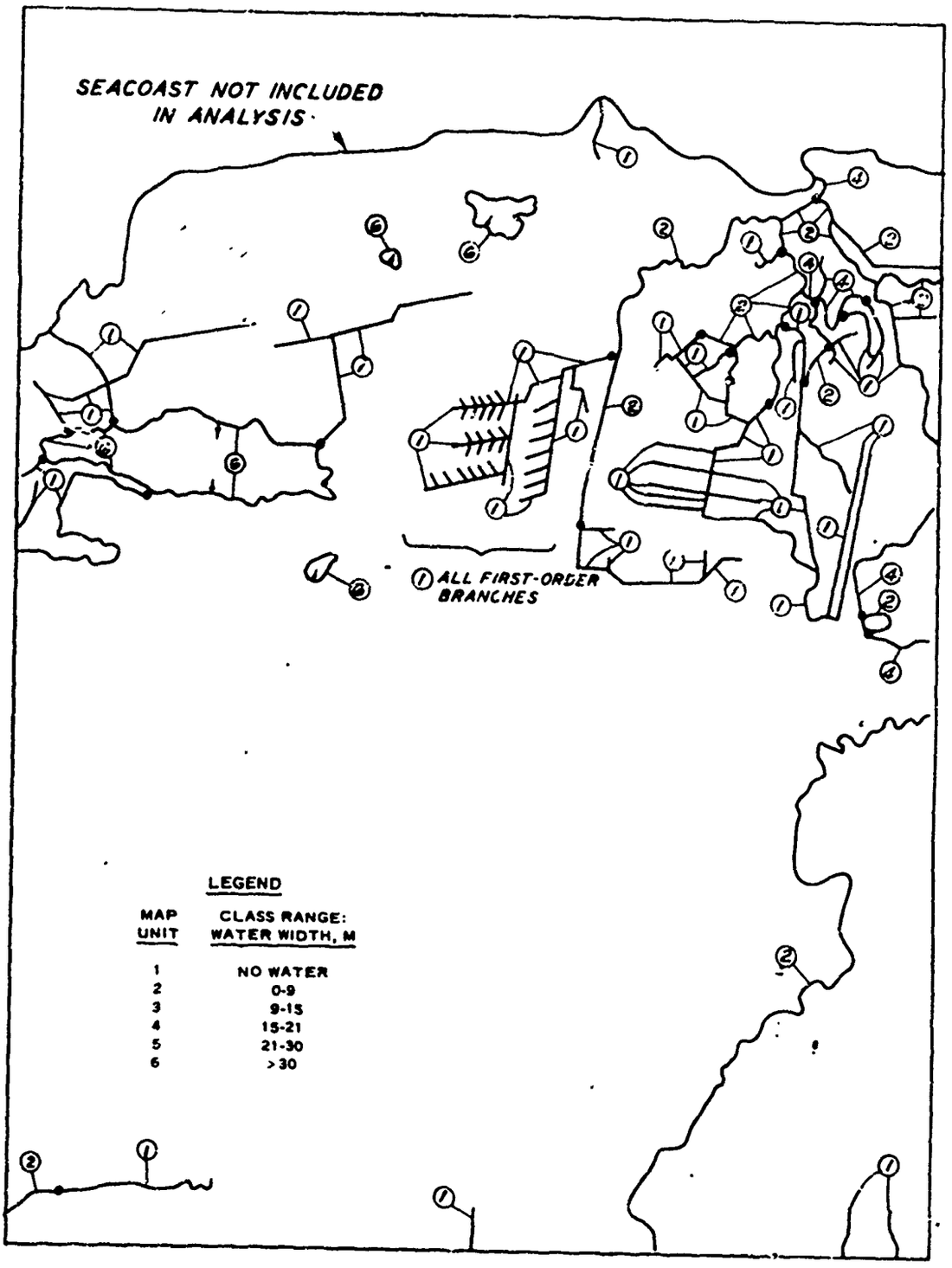


Fig. 30. Factor map. Hydrologic geometry: Water width

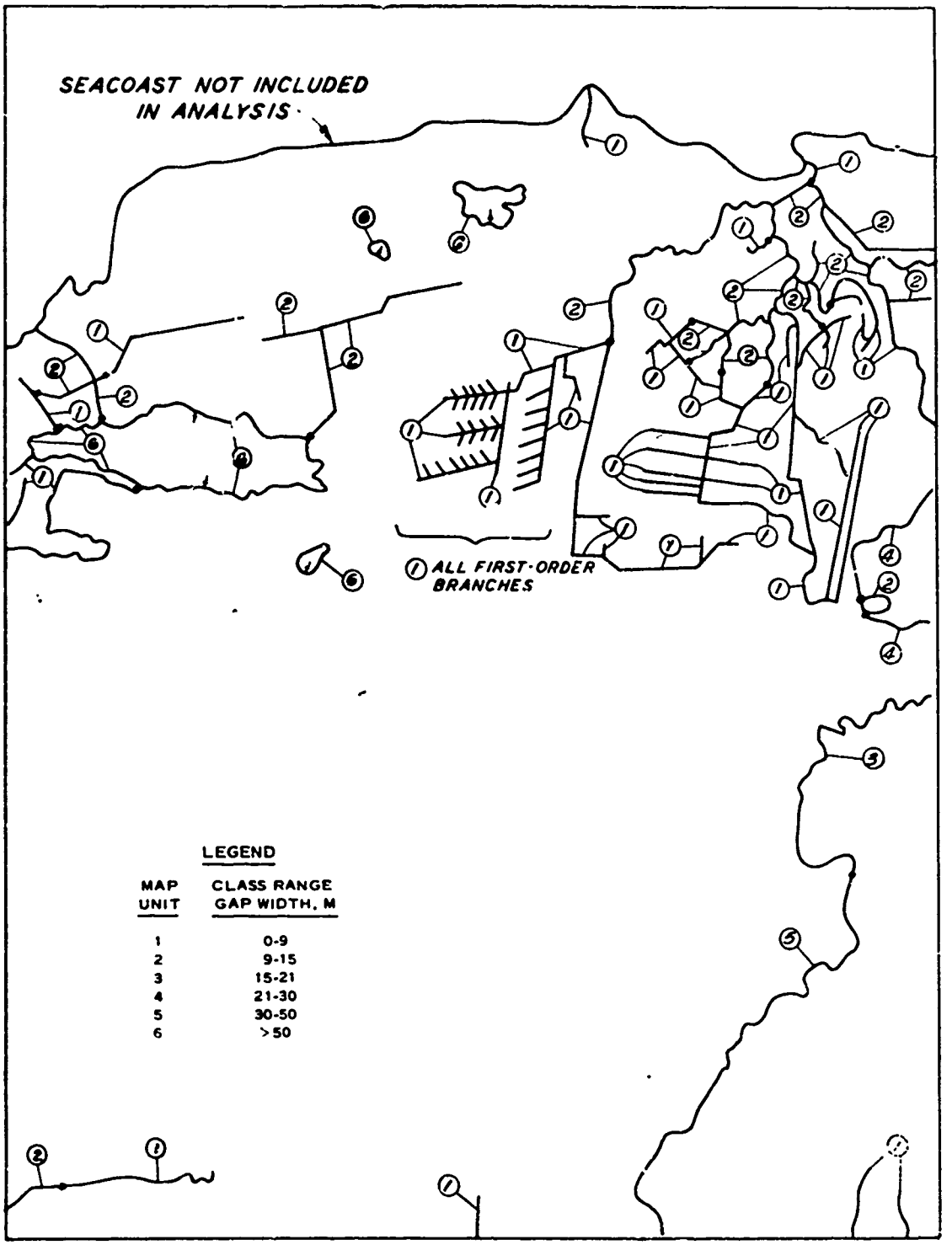


Fig. 31. Factor map. Hydrologic geometry: Gap width

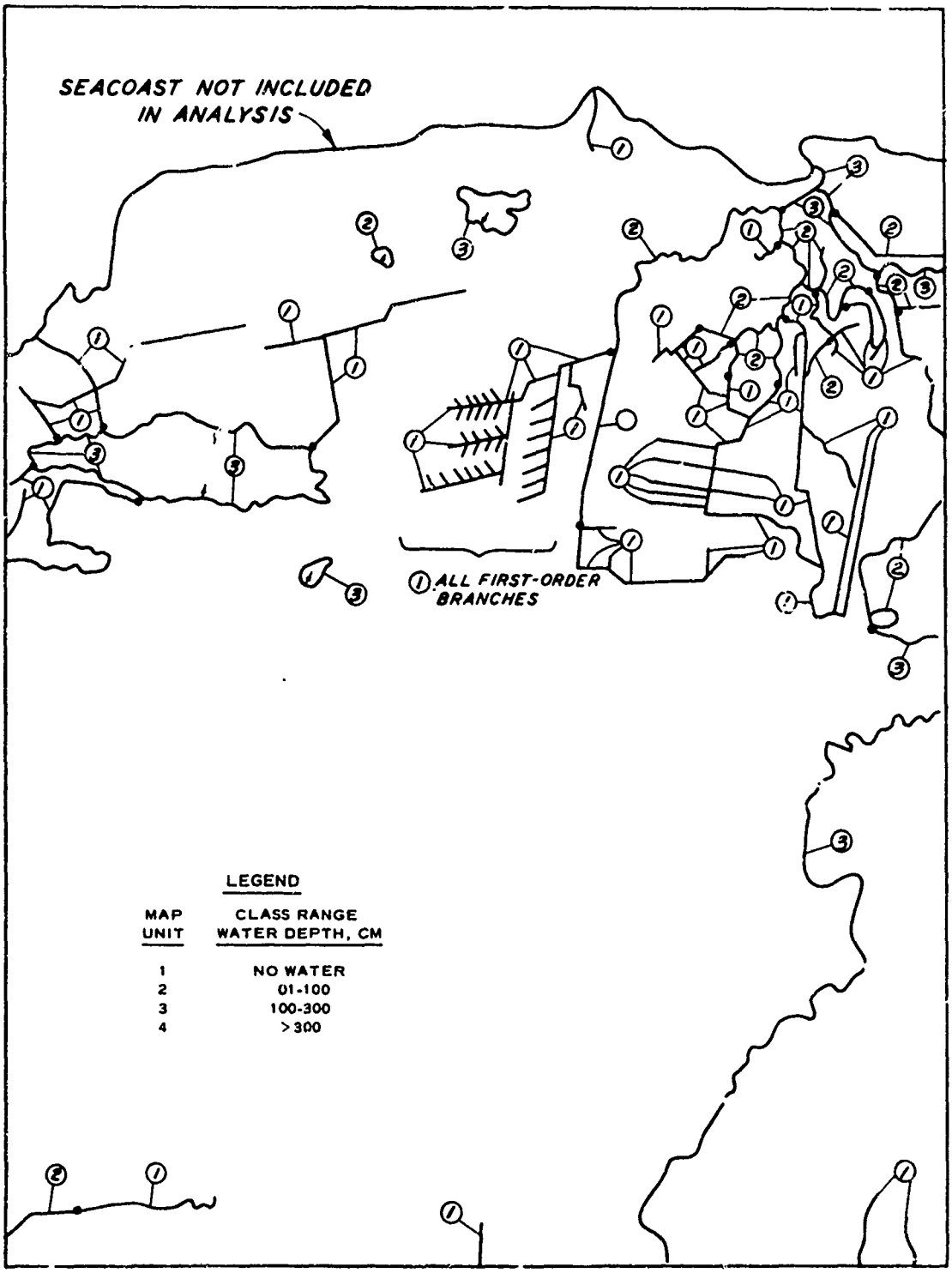


Fig. 32. Factor map. Hydrologic geometry: Water depth

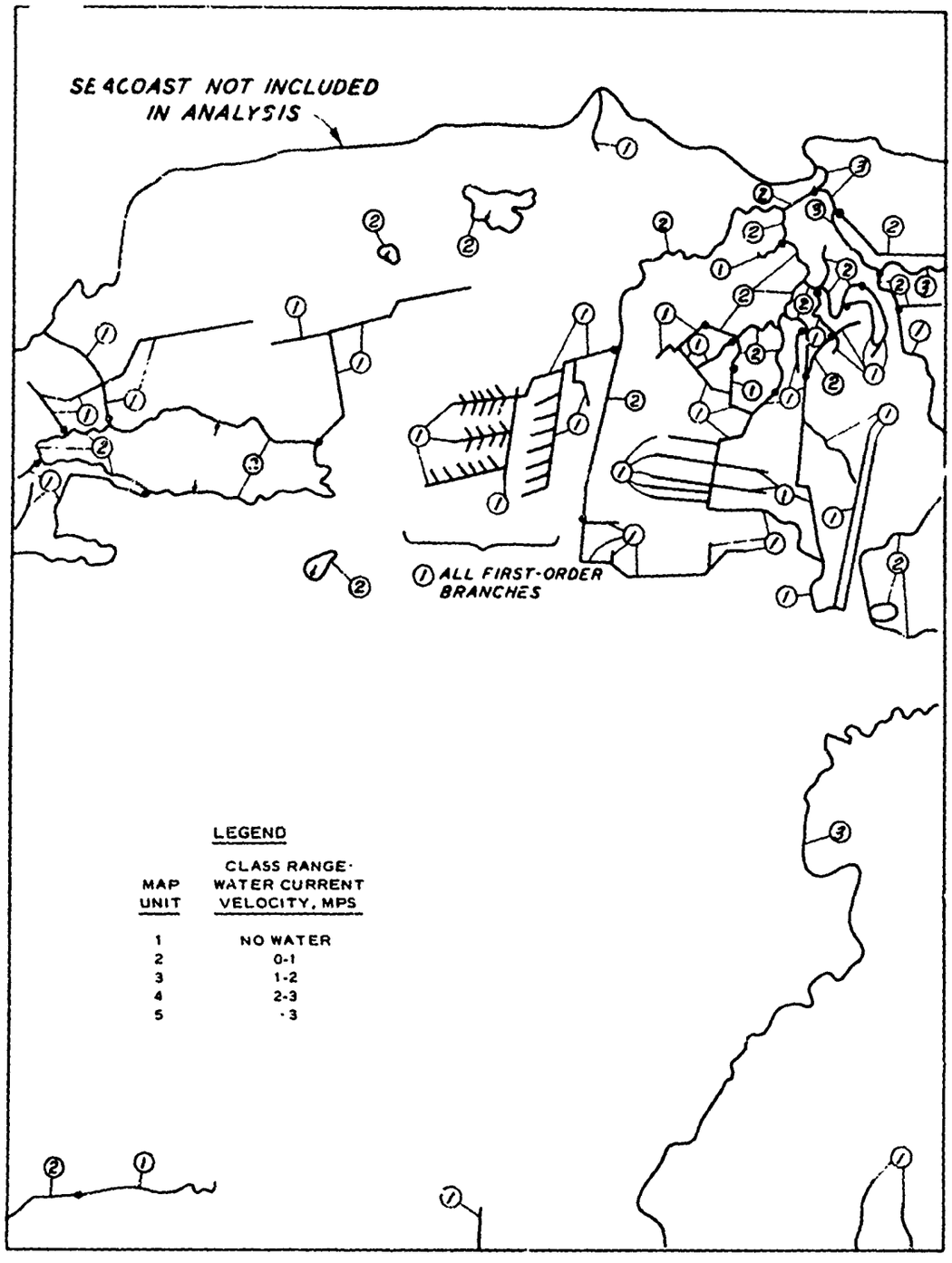
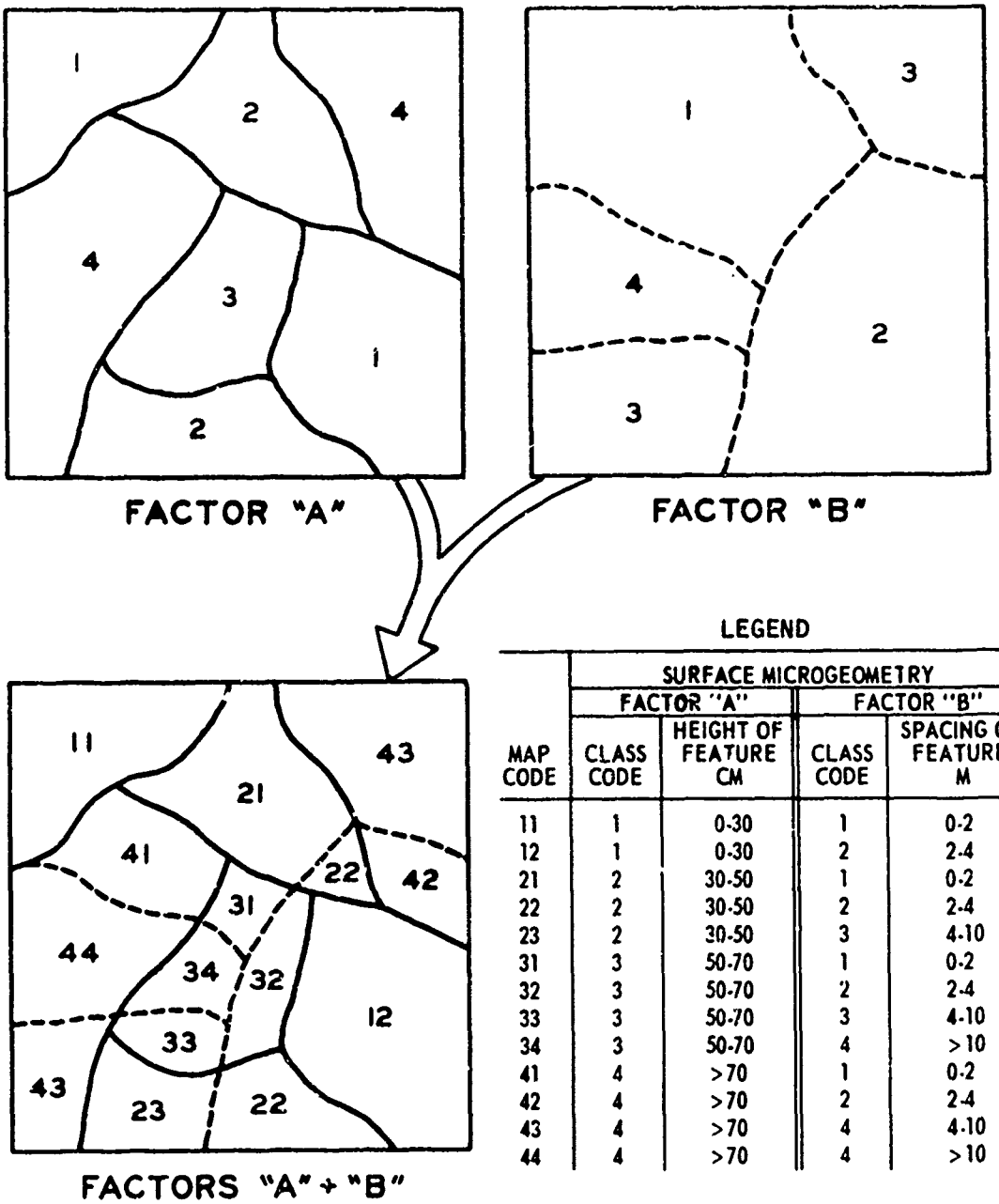


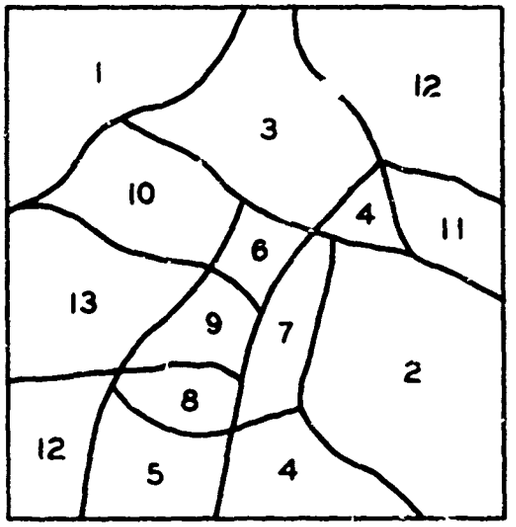
Fig. 33. Factor map. Hydrologic geometry: Water current velocity



LEGEND

MAP CODE	SURFACE MICROGEOMETRY			
	FACTOR "A"		FACTOR "B"	
	CLASS CODE	HEIGHT OF FEATURE CM	CLASS CODE	SPACING OF FEATURE M
11	1	0-30	1	0-2
12	1	0-30	2	2-4
21	2	30-50	1	0-2
22	2	30-50	2	2-4
23	2	30-50	3	4-10
31	3	50-70	1	0-2
32	3	50-70	2	2-4
33	3	50-70	3	4-10
34	3	50-70	4	>10
41	4	>70	1	0-2
42	4	>70	2	2-4
43	4	>70	4	4-10
44	4	>70	4	>10

Fig. 34. Method of "stacking" factor maps to create a factor complex map



FACTOR COMPLEX MAP

MAP UNIT	FACTOR COMPLEX IDENTIFICATION CODE FACTORS "A" "B"
1	11
2	12
3	21
4	22
5	23
6	31
7	32
8	33
9	34
10	41
11	42
12	43
13	44

Fig. 35. Technique for simplification of identification code

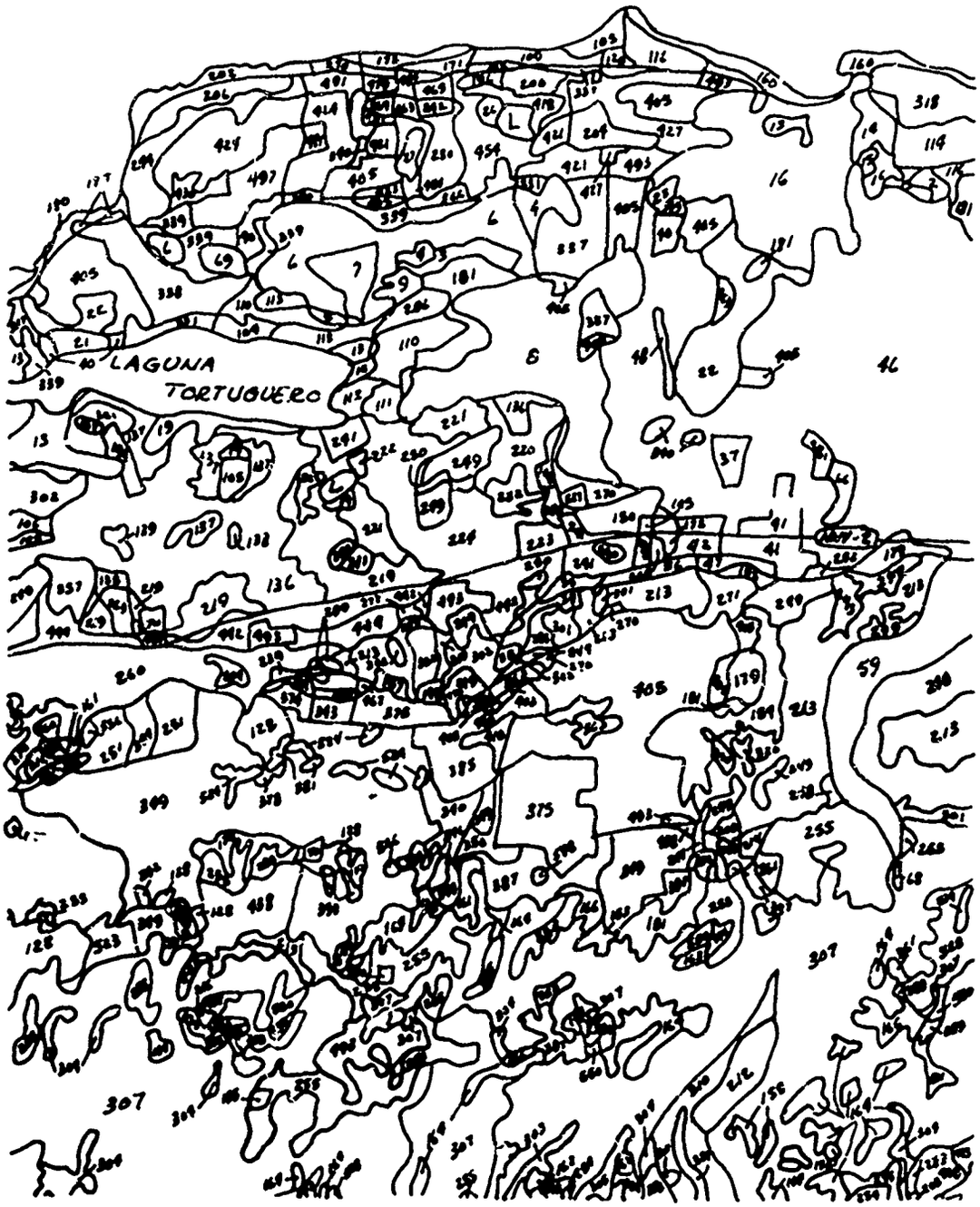


Fig. 36. Factor complex map. Areal terrain factor for cross-country speed for vehicles (M151) (sheet 1 of 2)

Legend
Cross Country Speed for Vehicles
Factor Complex Map

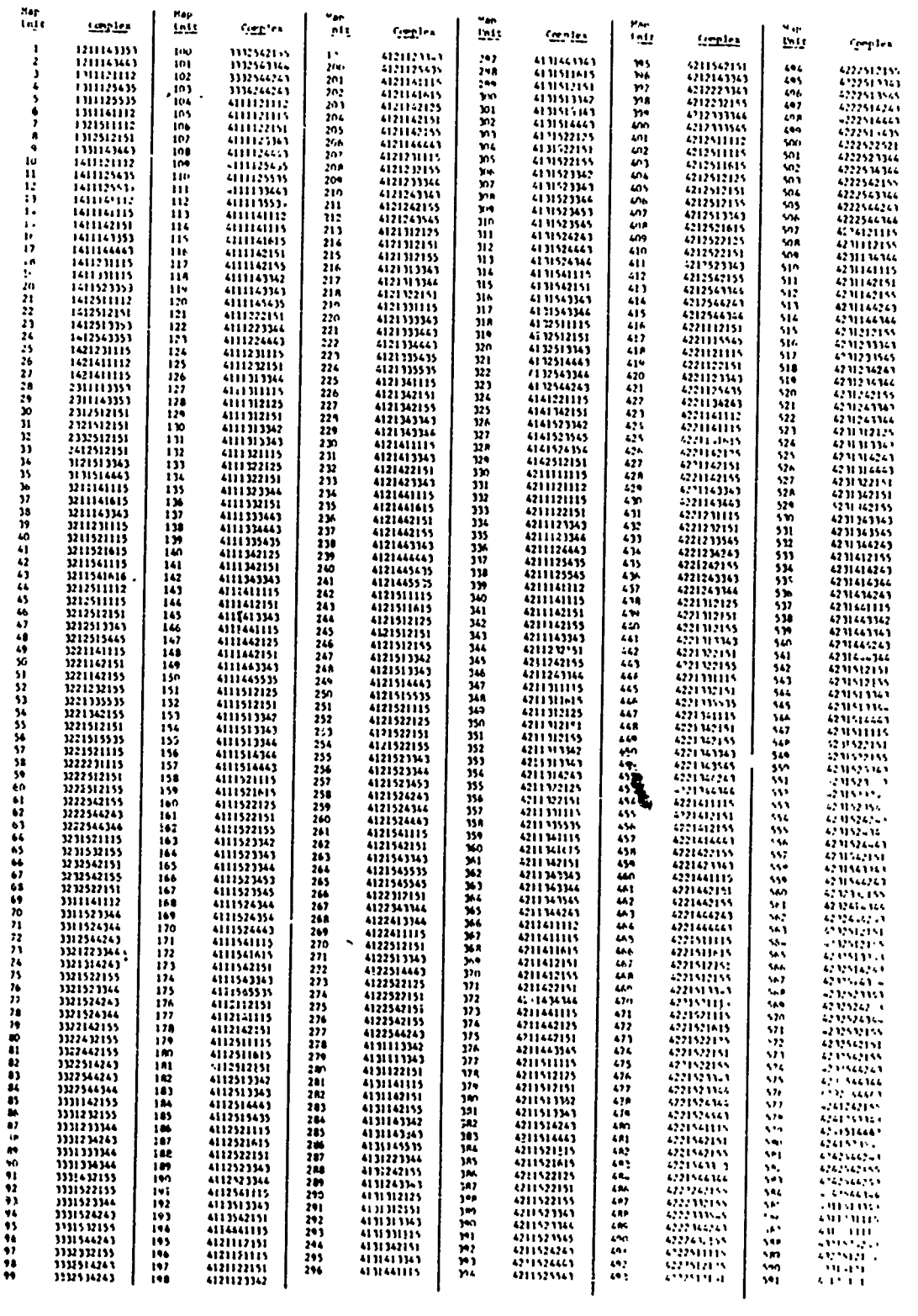


Fig. 36. (sheet 2 of 2)

Fig. 37. Factor complex map. Areal terrain factors for cross-country speed for personnel (sheet 1 of.2)

Cross-Country Movement of Personnel
Complex Legend

Map Unit	Complex No.
1	111112211
2	111122112
3	111125545
4	111125555
5	111131115
6	111141115
7	111142112
8	111142211
9	111143333
10	111212112
11	111212211
12	112112211
13	112113333
14	112141115
15	112143343
16	112712112
17	112712211
18	121111115
19	121112211
20	121121115
21	121131115
22	121212211
23	122141115
24	132142112
25	211131115
26	211143333
27	211212211
28	212212211
29	222212211
30	232212211
31	311111115
32	311112112
33	311112211
34	311121115
35	311121165
36	311131115
37	311141115
38	311141165
39	311142211
40	311211115
41	311212211
42	311213333
43	311231115
44	311233443
45	311241115
46	311241165
47	312121115
48	312124334
49	312131115
50	312212211
51	312222211
52	312244423
53	321212211
54	322112211
55	322114434
56	322114443
57	322121115
58	322122215
59	322124334
60	322124423
61	322124434
62	322132215
63	322134423
64	322135555
65	322141115
66	322142211
67	322142215
68	322144334
69	322212211
70	322212215
71	322214434
72	322224423
73	322231115
74	322232215
75	322242215
76	322244423
77	322244434
78	331212211
79	331214334
80	332124423
81	332124434
82	332132215
83	332134334
84	332134423
85	332134434
86	332212215
87	332214423
88	332214434
89	332242215
90	332244334
91	332244423
92	332244434
93	332344423
94	333212215
95	333244423
96	342244423
97	411111165
98	411112112
99	411112211
100	411113332
101	411113333
102	411121115
103	411122112
104	411122211
105	411125545
106	411125555
107	411131115
108	411133333
109	411133343
110	411135555
111	411141115
112	411141165
113	411142112
114	411142211
115	411143333
116	411143443
117	411144443
118	411145545
119	411145555
120	411212115
121	411211165
122	411212112
123	411212211
124	411213333
125	411213443
126	411215555
127	411221115
128	411222211
129	411225545
130	411233333
131	411235555
132	411241115
133	411241165
134	411242211
135	411243333
136	411311165
137	412111115
138	412111165
139	412112211
140	412112215
141	412113332
142	412113333
143	412114333
144	412114443
145	412115555
146	412121115
147	412121165
148	412122211
149	412122215
150	412122343
151	412123332
152	412123333
153	412123443
154	412124333
155	412124334
156	412124355
157	412124434
158	412124443
159	412124553
160	412125545
161	412125555
162	412131115
163	412132211
164	412132215
165	412133343
166	412133443
167	412134333
168	412134355
169	412134443
170	412135545
171	412141115
172	412141165
173	412142211
174	412142215
175	412143333
176	412143343
177	412143443
178	412144334
179	412144355
180	412144423
181	412144434
182	412144443
183	412145545
184	412145555
185	412211115
186	412212211
187	412212215
188	412213332
189	412213333
190	412213443
191	412214333
192	412214443
193	412214447
194	412221115
195	412222211
196	412223332
197	412223333
198	412223215
199	412234355
200	412242211
201	412242215
202	412244434
203	412244423
204	412244434
205	413244423
206	421111115
207	421112112
208	421112211
209	421113332
210	421114443
211	421121115
212	421124333
213	421131115
214	421133333
215	421133343
216	421134443
217	421135555
218	421141115
219	421141165
220	421142112
221	421142211
222	421143443
223	421145555
224	421211115
225	421211165
226	421212211
7	421213332
8	421213333
229	421241115
230	421241165
231	421242211
232	422111115
233	422111165
234	422112211
235	422112215
236	422113332
237	422113333
238	422114333
239	422114334
240	422114443
241	422121115
242	422121165
243	422122211
244	422122215
245	422123343
246	422123333
247	422124333
248	422124334
249	422124355
250	422124423
251	422124434
252	422124443
253	422125545
254	422125555
255	422131115
256	422132211
257	422132215
258	422133332
259	422134334
260	422134355
261	422134423
262	422134434
263	422134443
264	422135545
265	422135555
266	422141115
267	422141165
268	422142211
269	422142215
270	422143332
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272	422143343
273	422143415
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276	422144423
277	422144434
278	422144443
279	422145555
280	422211115
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282	422212215
283	422213332
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287	422214443
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291	422234355
292	422242112
293	422242215
294	422244334
295	422244423
296	422244434
297	423244423
298	423244434
299	431142211
300	431211115
301	431212211
302	432111115
303	432111165
304	432112211
305	432112215
306	432113332
307	432113343
308	432114423
309	432114434
310	432114443
311	432121115
312	432121165
313	432122211
314	432122215
315	432122343
316	432123332
317	432123343
318	432124355
319	432124365
320	432124423
321	432124434
322	432124443
323	432131115
324	432132211
325	432132215
326	432134423
327	432134434
328	432141115
329	432142211
330	432142215
331	432143332
332	432143333
333	432144334
334	432144355
335	432144423
336	432144434
337	432145555
338	432212211
339	432212215
340	432213333
341	432214355
342	432214423
343	432214443
344	432222211
345	432223333
346	432224334
347	432224423
348	432234423
349	432242211
350	432244355
351	432244423
352	433114434
353	433144434
354	433144443
355	433214423
356	433214434
357	433244423
358	433244434
359	442114434
360	442114443
361	442121115
362	442122211
363	442123332
364	442123333
365	442124334
366	442124354
367	442124434
368	442142215
369	442144334
370	442144434
371	442212215
372	442242215
373	442244423
374	442244434
375	443114423
376	443244423
377	443244434

Fig. 37. (sheet 2 of 2)

Fig. 38. Factor complex map. Areal terrain factors for HLZ construction effort (sheet 1 of 2)

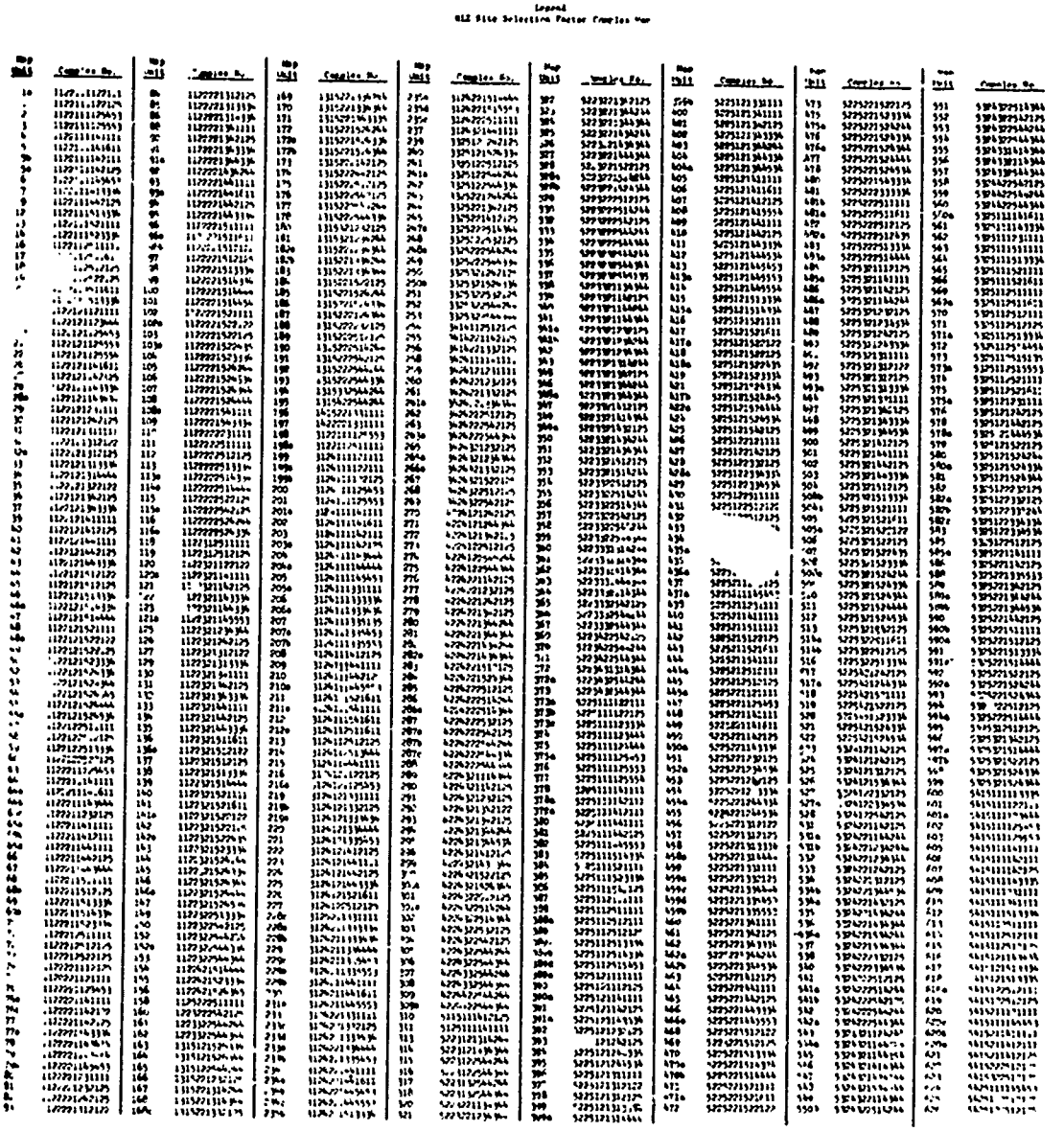


Fig. 38. (sheet 2 of 2)

Fig. 39. Factor complex map. Areal terrain factors for concealment characteristics (sheet 1 of 2)

Concealment Legend

Map Unit	Complex No.
1	1111115
2	1122115
3	1122131
4	1133323
5	1133332
6	1133343
7	1144233
8	1144324
9	1144443
10	1211114
11	1211615
12	1221112
13	1222115
14	1222131
15	1223423
16	1233323
17	1233332
18	1233333
19	1233343
20	1234433
21	1243344
22	1243515
23	1244233
24	1244324
25	1244344
26	1244443
27	1245533
28	1255425
29	1255525
30	1311115
31	1322115
32	1322131
33	1333323
34	1333423
35	1334433
36	1343344
37	1343515
38	1344233
39	1344324
40	1355425
41	1411115
42	1411615
43	1421112
44	1422115
45	1422131
46	1433323
47	1433332
48	1433333
49	1433343
50	1434433
51	1443344
52	1443515
53	1444233
54	1444324
55	1444443
56	1455425
57	1455525
58	2111115
59	2111615
60	2121112
61	2122115
62	2122131
63	2133323
64	2133332
65	2134433
66	2144233
67	2144324
68	2144443
69	2145435
70	2155425
71	2222131
72	2311115
73	2322115
74	2343515
75	2322115
76	2443344
77	2444233
78	2444324
79	3211615
80	3222131
81	3233323
82	4422131

Fig. 39. (sheet 2 of 2)

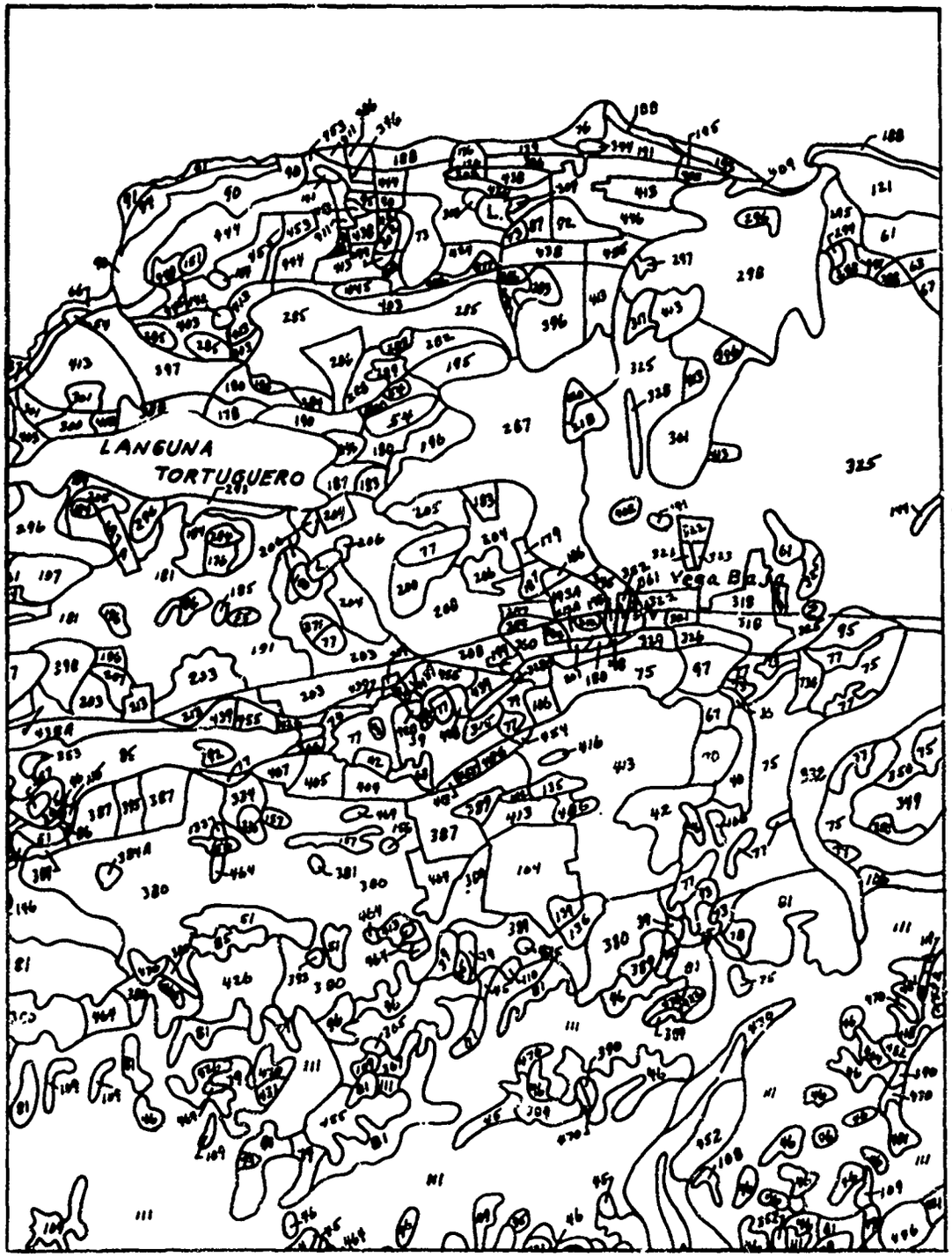


Fig. 40. Factor complex map. Areal terrain factors for cover characteristics (sheet 1 of 2)

Israel
Vector Complex Cover
(Weapons Effectiveness)

Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.
1	112121212	102A	141324424	202	341212111	301	514121212	402	[illegible]
2	112412111	103	141311111	203	341213111	302	514211111	403	[illegible]
3	133112433	104	141311161	204	341213333	303	514211211	404	[illegible]
5	133114424	105	141311212	205	341213443	304	514221111	405	[illegible]
6	133211424	106	141311333	206	341213444	305	521111333	405A	[illegible]
7	133211434	107	141311444	207	[illegible]	307	521113111	406	[illegible]
8	133212424	108	141312111	208	[illegible]	308	521114333	407	[illegible]
9	133212433	109	[illegible]	209	341214111	309	[illegible]	408	[illegible]
10	133212434	110	[illegible]	210	341214161	310	521121212	409	[illegible]
11	[illegible]	111	141312333	211	341214212	311	521221212	410	[illegible]
12	[illegible]	112	141312424	212	341214545	312	521321212	411	[illegible]
13	[illegible]	113	141312433	212A	341214555	313	531121111	412	[illegible]
14	133213434	114	141312434	213	341221111	314	[illegible]	413	[illegible]
15	133214212	115	141312444	214	341221212	315	[illegible]	414	[illegible]
16	133221212	115A	141312453	215	341221344	316	[illegible]	415	[illegible]
17	133224212	116	141313212	216	341314111	317	[illegible]	416	[illegible]
18	133224424	117	141314211	217	342112111	318	[illegible]	417	[illegible]
19	133224433	118	141314212	218	342112212	319	[illegible]	418	[illegible]
20	133312212	119	141314333	219	342112433	320	[illegible]	419	[illegible]
21	133312424	120	141314433	220	342112545	321	[illegible]	420	[illegible]
22	133312433	120A	141314555	221	342112555	322	[illegible]	421	[illegible]
23	133313212	121	141321111	222	342114111	323	[illegible]	422	[illegible]
24	133313424	122	141321212	223	342114212	324	[illegible]	423	[illegible]
25	133313433	123	141321333	224	342121111	325	[illegible]	424	[illegible]
26	133313434	124	141324424	225	342121212	326	[illegible]	425	[illegible]
28	133314332	125	141324433	226	[illegible]	328	[illegible]	426	[illegible]
29	133321212	126	141412211	227	342124433	328A	[illegible]	427	[illegible]
30	133321424	127	141412212	228	342211212	329	[illegible]	428	[illegible]
31	133321434	128	141412333	229	342213212	330	[illegible]	429	[illegible]
32	133324212	129	141412434	230	342213434	331	[illegible]	430	[illegible]
33	[illegible]	132	142111212	231	342214212	332	[illegible]	431	[illegible]
34	133324433	133	142111333	232	342221212	333	[illegible]	432	[illegible]
35	133424424	134	142111433	233	342221434	334	[illegible]	433	[illegible]
36	141111111	135	[illegible]	234	[illegible]	335	[illegible]	434	[illegible]
38	141111211	136	142112212	235	342224433	335A	[illegible]	435	[illegible]
39	141111212	137	142112333	236	342312212	336	[illegible]	436	[illegible]
40	141111333	138	[illegible]	237	342312433	337	[illegible]	437	[illegible]
41	141111433	139	142114212	238	[illegible]	338	[illegible]	438	[illegible]
42	141111444	140	142114333	239	[illegible]	339	[illegible]	438A	[illegible]
43	141112111	141	142121111	240	342323212	340	[illegible]	439	[illegible]
44	141112211	142	142121212	241	342324424	341	[illegible]	440	[illegible]
45	141112212	143	142121333	242	342324434	342	[illegible]	441	[illegible]
46	141112333	144	142121513	243	[illegible]	343	[illegible]	442	[illegible]
47	141112344	145	142211333	244	[illegible]	344	[illegible]	443	[illegible]
48	141112424	146	142211444	245	442114211	345	[illegible]	444	[illegible]
49	141112433	147	142212212	246	442114434	346	[illegible]	445	[illegible]
50	141112434	148	142212333	247	442121212	347	[illegible]	446	[illegible]
51	141112444	149	142212545	248	442124424	348	[illegible]	447	[illegible]
52	141112453	150	142213111	249	442121434	349	[illegible]	448	[illegible]
53	141112545	151	142214111	250	442211212	350	[illegible]	449	[illegible]
54	141112555	152	142214212	251	442212434	351	[illegible]	450	[illegible]
55	141113111	153	141214333	252	[illegible]	352	[illegible]	451	[illegible]
56	141113212	154	142221111	253	[illegible]	353	[illegible]	452	[illegible]
57	141113243	155	142224424	254	442214212	354	[illegible]	453	[illegible]
58	141113323	156	142311212	255	442214424	355	[illegible]	454	[illegible]
59	141113344	157	142311333	256	442214434	356	[illegible]	455	[illegible]
60	141113433	158	[illegible]	257	442221212	357	[illegible]	456	[illegible]
61	141114111	159	142312333	258	442221424	358	[illegible]	457	[illegible]
62	141114161	160	142312434	259	442221434	359	[illegible]	458	[illegible]
63	141114212	161	142314111	260	442223212	360	[illegible]	459	[illegible]
64	141114333	162	142314212	261	442224212	361	[illegible]	460	[illegible]
65	141114555	163	142314333	262	442224424	362	[illegible]	461	[illegible]
66	141121111	164	142324212	263	442224434	363	[illegible]	462	[illegible]
67	141121212	165	142324424	264	442311212	364	[illegible]	463	[illegible]
68	141121333	166	142324434	265	[illegible]	365	[illegible]	464	[illegible]
69	141121344	167	142411161	266	442312212	366	[illegible]	465	[illegible]
70	141121434	168	332112111	267	442312434	367	[illegible]	466	[illegible]
70A	[illegible]	169	332213212	268	442313212	368	[illegible]	467	[illegible]
71	141122212	170	332221212	268A	442313434	369	[illegible]	468	[illegible]
72	141131333	171	332224212	269	442314212	370	[illegible]	469	[illegible]
73	141211111	171A	332321212	271	442314424	371	[illegible]	470	[illegible]
73A	141211161	172	332324212	272	442314434	372	[illegible]	471	[illegible]
74	141211212	173	[illegible]	273	442321212	373	[illegible]	472	[illegible]
75	141211333	174	341111212	274	442321424	374	[illegible]	473	[illegible]
76	141211433	176	341112111	275	442321434	375	[illegible]	473A	[illegible]
77	141211444	177	341112161	276	442323212	376	[illegible]	474	[illegible]
78	141212111	178	341112211	277	[illegible]	377	[illegible]	475	[illegible]
79	141212212	179	341112545	278	[illegible]	378	[illegible]	476	[illegible]
80	141212243	180	341112555	279	[illegible]	379	[illegible]	477	[illegible]
81	141212333	181	341113111	280	[illegible]	380	[illegible]	478	[illegible]
82	141212424	182	341113212	281	[illegible]	381	[illegible]	479	[illegible]
83	141212433	183	341113333	282	513112211	382	[illegible]	480	[illegible]
84	141212434	184	[illegible]	283	513112545	383	[illegible]	481	[illegible]
85	141212444	185	341113444	284	513112555	384	[illegible]	482	[illegible]
86	141212453	186	341113545	285	[illegible]	385	[illegible]	483	[illegible]
87	[illegible]	187	341113555	286	513121211	386	[illegible]	484	[illegible]
88	[illegible]	188	341114111	287	513121212	387	[illegible]	485	[illegible]
89	141213212	189	341114161	288	513114211	388	[illegible]	486	[illegible]
90	141214111	190	341114211	289	[illegible]	389	[illegible]	487	[illegible]
91	141214161	191	341114212	290	[illegible]	390	[illegible]	488	[illegible]
92	141214212	192	341114344	291	[illegible]	391	[illegible]	489	[illegible]
93	141214333	193	341114545	292	[illegible]	392	[illegible]	490	[illegible]
94	141214344	193A	[illegible]	293	[illegible]	393	[illegible]	491	[illegible]
95	141221111	194	341121111	294	[illegible]	394	[illegible]	492	[illegible]
96	141221212	195	[illegible]	295	[illegible]	395	[illegible]	493	[illegible]
97	141221333	196	341121555	296	[illegible]	396	[illegible]	494	[illegible]
98	141221433	197A	341144111	297	[illegible]	397	[illegible]	495	[illegible]
99	141222212	198	[illegible]	298	[illegible]	398	[illegible]	496	[illegible]
100	141222444	199	[illegible]	299	[illegible]	399	[illegible]	497	[illegible]
101	141223111	200	341211444	300	[illegible]	400	[illegible]	498	[illegible]
102	141224211	201	[illegible]					499	[illegible]
								[illegible]	[illegible]
								[illegible]	[illegible]
								[illegible]	[illegible]
								[illegible]	[illegible]
								[illegible]	[illegible]

Fig. 40. (sheet 2 of 2)

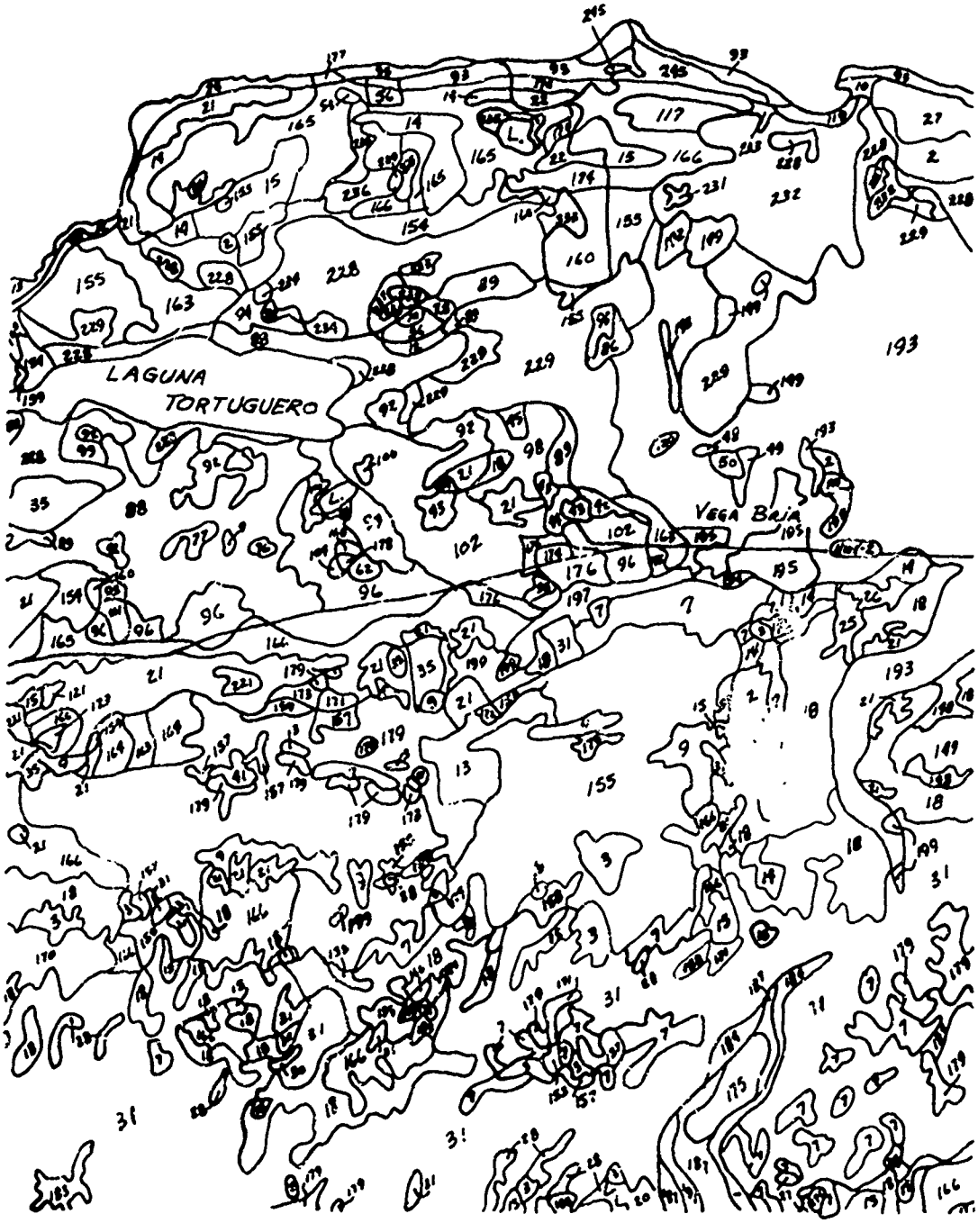


Fig. 41. Factor complex map. Areal terrain factors for airfield construction effort (sheet 1 of 2)

Legend
Airfield Construction
Effort Complex Map

Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.
1	111224111	63	124234324	125	524224211	187	524254453
2	114224111	64	124244324	126	524224212	188	524254461
3	114224112	65	124244424	127	524224243	189	524254412
4	114224114	66	124254112	128	524224245	190	524254433
5	114224131	67	133153212	129	524224311	191	524254453
6	114224132	68	133153224	130	524224312	192	533252111
7	114224133	69	133153233	131	524224333	193	533252112
8	114224134	70	133153234	132	524234112	194	533252133
9	114224144	71	133153312	133	524234124	195	533252161
10	114224145	72	133153324	134	524234134	196	533252212
11	114224153	73	133153333	135	524234212	197	533252255
12	114224155	74	133153334	136	524234221	198	533252312
13	114224161	75	141151214	137	524234232	199	533252344
14	114224211	76	144224111	138	524234234	200	533254324
15	114224212	77	144224143	139	524234312	201	534224212
16	114224213	78	144224144	140	524234324	202	534234324
17	114224224	79	511141112	141	524234332	203	534234334
18	114224233	80	314224112	142	524234334	204	534234434
19	114224234	81	314224133	143	524234412	205	534244112
20	114224243	82	314224311	144	524234424	206	534244153
21	114224244	83	314224312	145	524234433	207	534244212
22	114224245	84	314224333	146	524234434	208	534244224
23	114224253	85	314224361	147	524244211	209	534244234
24	114224255	86	314242112	148	524251233	210	534244253
25	114224261	87	314242145	149	524252112	211	534244312
26	114224264	88	314244111	150	524252144	212	534244324
27	114224311	89	314244112	151	524252161	213	534244334
28	114224312	90	314244133	152	524252212	214	534244353
29	114224324	91	314244142	153	524253212	215	534244424
30	114224332	92	314244143	154	524254111	216	534254112
31	114224333	93	314244145	155	524254112	217	534254124
32	114224334	94	314244155	156	524254124	218	534254133
33	114224342	95	314244161	157	524254133	219	534254134
34	114224343	96	314244211	158	524254143	220	534254153
35	114224344	97	314244212	159	524254144	221	534254212
36	114224355	98	314244233	160	524254145	222	534254224
37	114224361	99	314244243	161	524254152	223	534254234
38	114224412	100	314244244	162	524254153	224	534254253
39	114224433	101	314244245	163	524254155	225	534254312
40	114224434	102	314244255	164	524254161	226	534254324
41	114242112	103	314244261	165	524254211	227	534254334
42	114244112	104	314244311	166	524254212	228	541151111
43	114244145	105	314244312	167	524254213	229	541151112
44	114244155	106	314254312	168	524254222	230	541511131
45	114244233	107	424244112	169	524254224	231	541511132
46	114244311	108	424244124	170	524254232	232	541511133
47	114244333	109	424244134	171	524254233	233	541511145
48	114252111	110	424244212	172	524254234	234	541511155
49	114252133	111	424244224	173	524254244	235	541512111
50	114252161	112	424244234	174	524254245	236	541512112
51	114254124	113	424244312	175	524254253	237	541513111
52	114254133	114	424244324	176	524254255	238	541513143
53	114254211	115	424244333	177	524254261	239	541513551
54	114254212	116	424244334	178	524254311	240	542151111
55	114254234	117	424254112	179	524254312	241	542151112
56	114254245	118	511151112	180	524254313	242	542151211
57	114254312	119	514244145	181	524254323	243	542151212
58	114254324	120	514252111	182	524254324	244	542151312
59	114254332	121	514254244	183	524254333	245	542251112
60	114254333	122	524141133	184	524254334	246	544254112
61	114254324	123	524224112	185	524254343	247	544254131
62	124224244	124	524224133	186	524254344		

Fig. 41. (sheet 2 of 2)

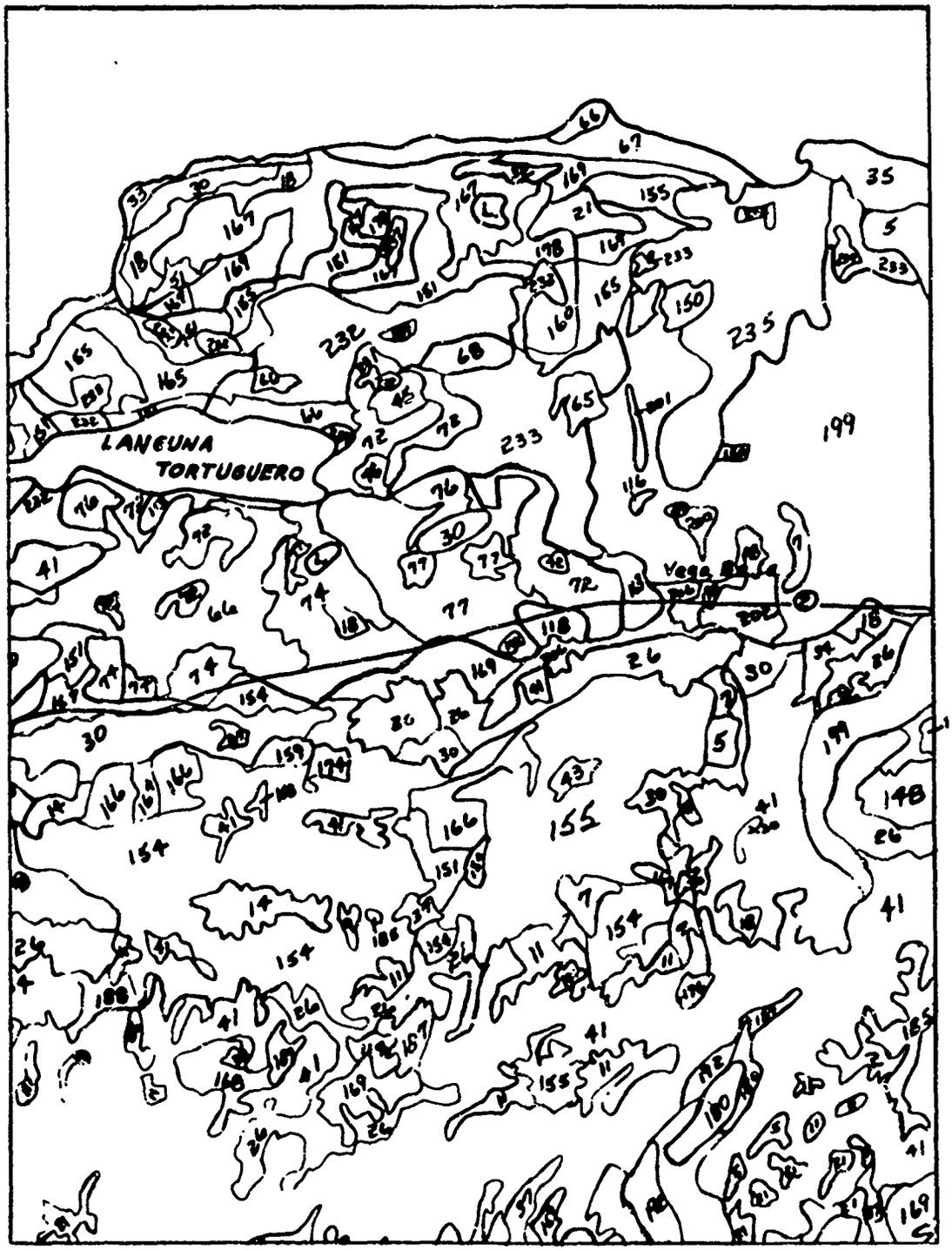


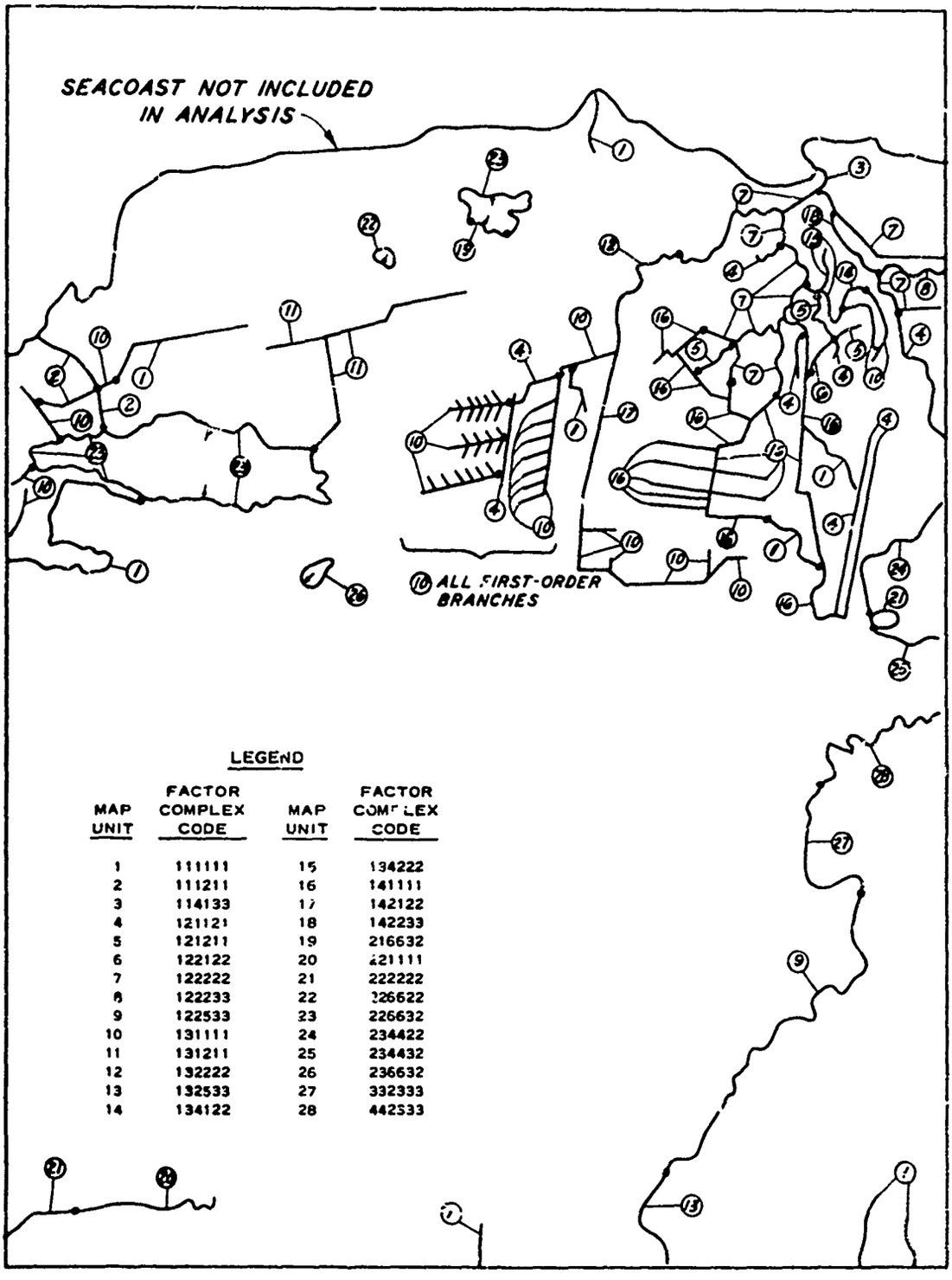
Fig. 42. Factor complex map. Areal terrain factors for bunker construction effort (sheet 1 of 2)

Legend

Worker Construction Factor Complex Map

Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.	Map Unit	Complex No.
1	1112242111	63	13315422344	125	52[illegible]	187	52[illegible]
2	1122413344	64	3142241111	126	52[illegible]	188	52[illegible]
3	1142224334	65	3142421125	127	52[illegible]	189	5242543334
4	1142231334	66	3142441111	128	52[illegible]	190	5242543441
5	1142241111	67	3142441122	129	5242313344	191	5242543444
6	1142241122	68	3142441125	130	5242332344	192	5242543534
7	1142241125	69	3142441234	131	52[illegible]	193	5242543544
8	1142241134	70	3142441244	132	5242341244	194	5242543611
9	1142241145	71	3142441253	133	5242341344	195	5242544125
10	1142241325	72	3142441553	134	5242342125	196	5242544412
11	1142241334	73	3142441611	135	5242342244	197	5242544534
12	1142241344	74	3142442111	136	5242342344	198	5332521111
13	1142241345	75	3142442125	137	5242343125	199	5332521125
14	1142241444	76	3142442434	138	5242343144	200	5332521334
15	1142241534	77	3142442444	139	5242343344	201	5332521454
16	1142241553	78	3142442611	140	5242343325	202	5332521611
17	1142241611	79	3142443111	141	5242343344	203	5332522111
18	1142242111	80	3142444434	142	5242344125	204	5332522125
19	1142242114	81	3342541125	143	5242344244	205	5332522334
20	1142242122	82	3342541244	144	5242343344	206	5332532334
21	1142242125	83	3342541334	145	5242343344	207	5342441124
22	1142242134	84	3342542125	146	5242511125	208	5342441125
23	1142242225	85	3342542244	147	5242511334	209	5342441244
24	1142242244	86	3342542334	148	5242512122	210	5342441344
25	1142242311	87	3342542344	149	5242512334	211	5342441534
26	1142242334	88	3342543125	150	5242521125	212	5342442125
27	1142242344	89	3342543244	151	5242541111	213	5342442225
28	1142242425	90	3342543334	152	5242541115	214	5342442244
29	1142242435	91	3342543344	153	5242541121	215	5342442344
30	1142242444	92	3422541125	154	5242541122	216	5342442534
31	1142242445	93	3431422325	155	5242541125	217	5342443344
32	1142242453	94	3432323125	156	5242541322	218	5342443534
33	1142242611	95	3432422125	157	5242541325	219	5342443534
34	1142242644	96	3432422244	158	5242541334	220	5342444344
35	1142243111	97	3432423125	159	5242541344	221	5342541125
36	1142243114	98	3442422125	160	5242541453	222	5342541244
37	1142243125	99	3442422344	161	5242541525	223	5342541344
38	1142243244	100	3442423125	162	5242541534	224	5342542125
39	1142243313	101	4232442125	163	5242541553	225	5342542244
40	1142243325	102	4232443125	164	5242541554	226	5342542334
41	1142243334	103	4242343244	165	5242541555	227	5342542344
42	1142243344	104	4242441125	166	5242541611	228	5342542534
43	1142243444	105	4242441344	167	5242542111	229	5342543125
44	1142243534	106	4242442125	168	5242542122	230	5342543344
45	1142243553	107	4242442144	169	5242542125	231	5411111111
46	1142243611	108	4242442244	170	5242542224	232	5411121111
47	1142244334	109	4242442344	171	5242542225	233	5411511111
48	1142411111	110	4242443125	172	5242542325	234	5411511134
49	1142521111	111	4242443244	173	5242542332	235	5411511335
50	1142541125	112	4242443344	174	5242542334	236	5411511453
51	1242521125	113	5111511111	175	5242542344	237	5411512111
52	1331433125	114	5142243334	176	5242542434	238	5411513335
53	1331531125	115	5142241125	177	5242542444	239	5411514553
54	1331531334	116	5142521111	178	5242542453	240	5411541111
55	1331532125	117	5142542334	179	5242542525	241	5421511111
56	1331532244	118	5142542553	180	5242542534	242	5421511125
57	1331532334	119	5211541453	181	5242542544	243	5421511134
58	1331532344	120	5222542125	182	5242542611	244	5421511335
59	1331533125	121	5222542534	183	5242543111	245	5421511453
60	1331533344	122	5222543125	184	5242544124	246	5421511[illegible]
61	1331533334	123	5232343125	185	5242543125		
62	1331533344	124	5232343244	186	5242543225		

Fig. 42. (sheet 2 of 2)



MAP UNIT	FACTOR COMPLEX CODE	MAP UNIT	FACTOR COMPLEX CODE
1	111111	15	134222
2	111211	16	141111
3	114133	17	142122
4	121121	18	142233
5	121211	19	216632
6	122122	20	221111
7	122222	21	222222
8	122233	22	226622
9	122533	23	226632
10	131111	24	234422
11	131211	25	234432
12	132222	26	236632
13	132533	27	332333
14	134122	28	442533

Fig. 43. Factor complex map. Linear features for cross-country speed for vehicles and cross-country speed for personnel

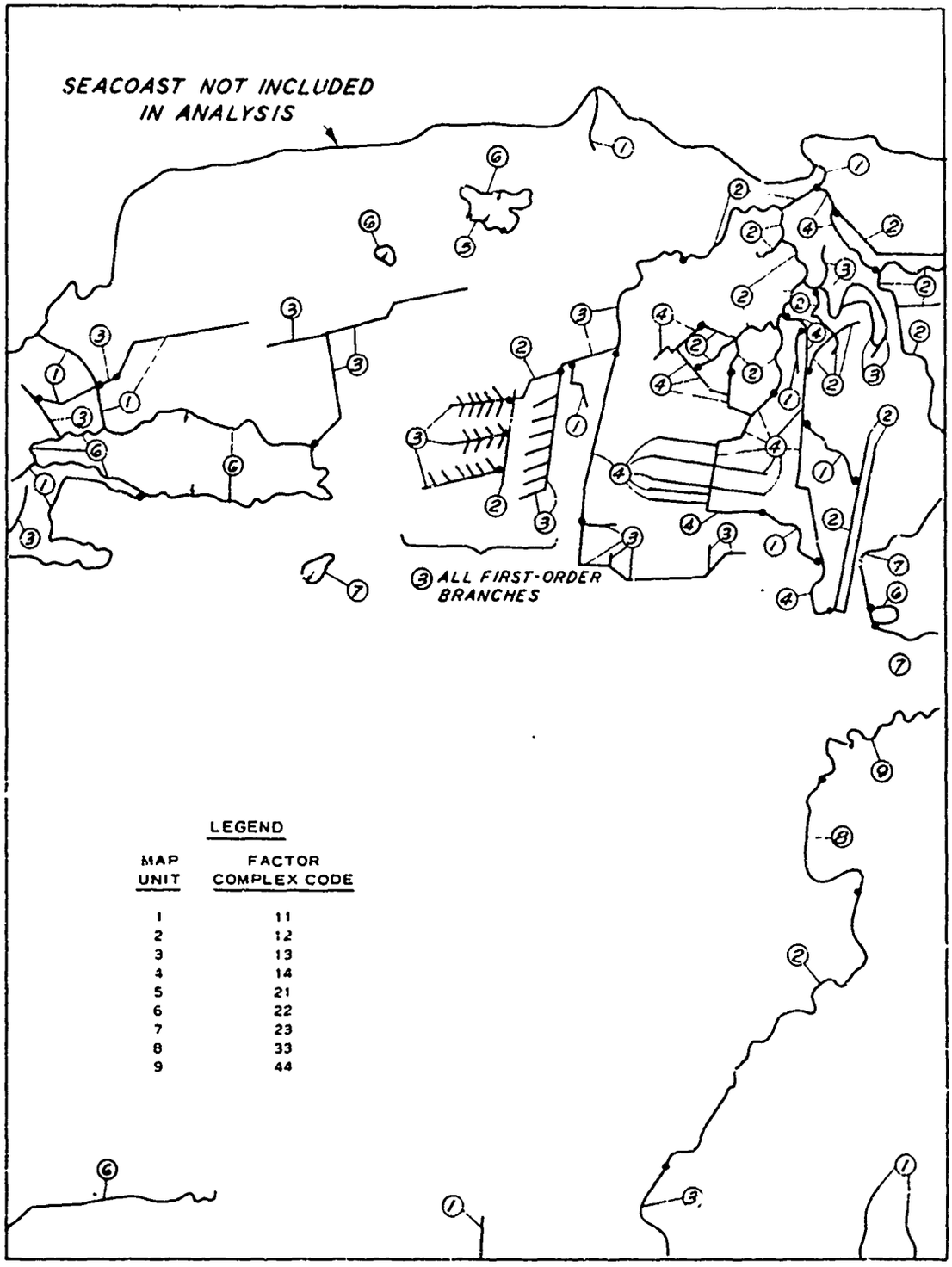
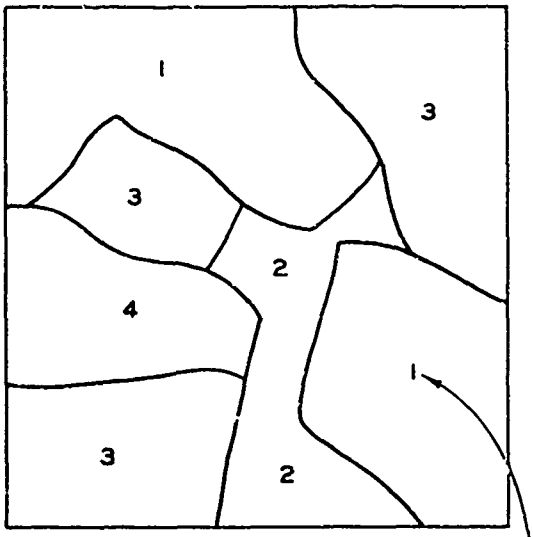


Fig. 44. Factor complex map. Linear features for concealment and cover characteristics

PERFORMANCE PREDICTION MAP



FACTOR COMPLEX MAP UNIT	FACTOR CODE	"MODEL" CALCULATION* (A + 8B = P)	PERFORMANCE CLASS**
1	11	15 + 8.10 = 23	1
2	12	15 + 8.30 = 39	1
3	21	40 + 8.10 = 48	1
4	22	40 + 8.30 = 64	2
5	23	40 + 8.70 = 96	3
6	31	60 + 8.10 = 68	2
7	32	60 + 8.30 = 84	2
8	33	60 + 8.70 = 116	3
9	34	60 + 8.15 = 180	4
10	41	90 + 8.10 = 98	3
11	42	90 + 8.30 = 114	3
12	43	90 + 8.70 = 146	3
13	44	90 + 8.15 = 210	4

* MIDPOINTS OF CLASS RANGES USED FOR CALCULATION.

** PERFORMANCE CLASSES:

CLASS CODE	PERFORMANCE VALUE RANGE
1	20-50
2	51-90
3	91-150
4	151-250

Fig. 45. Preparation of final MGI product map

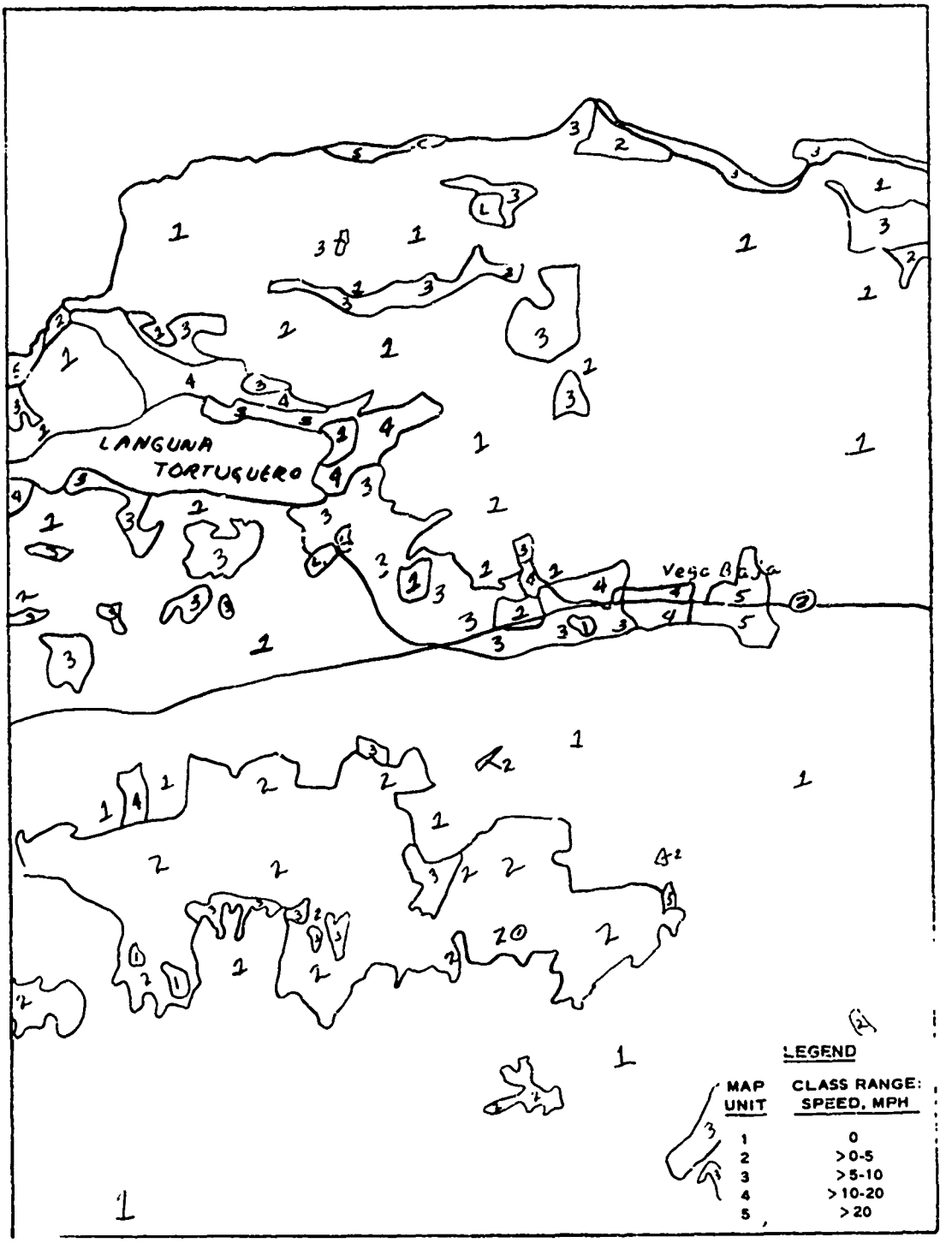


Fig. 46. MGI product map. Cross-country speed for vehicles (M151)

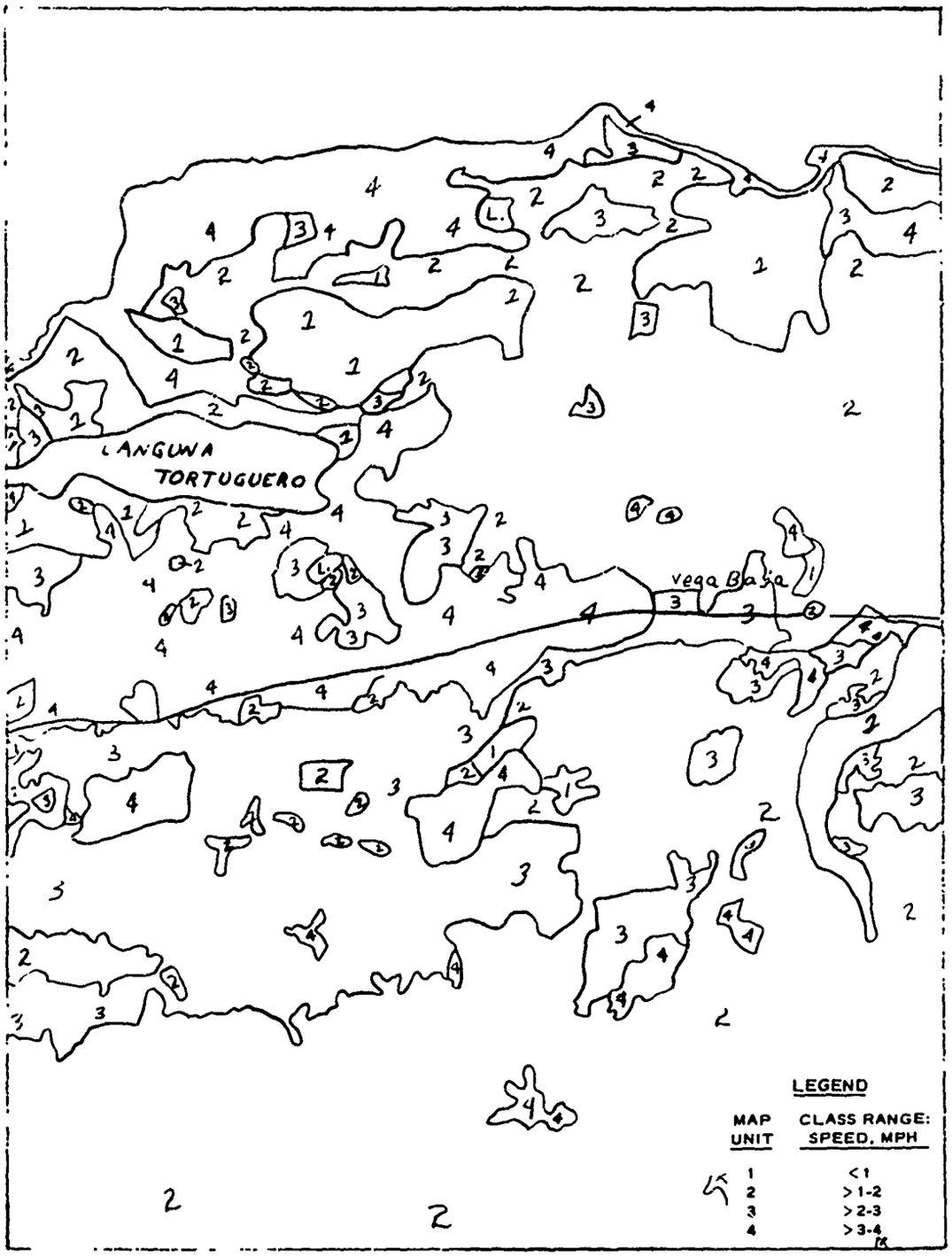


Fig. 47. MGI product map. Cross-country speed for personnel

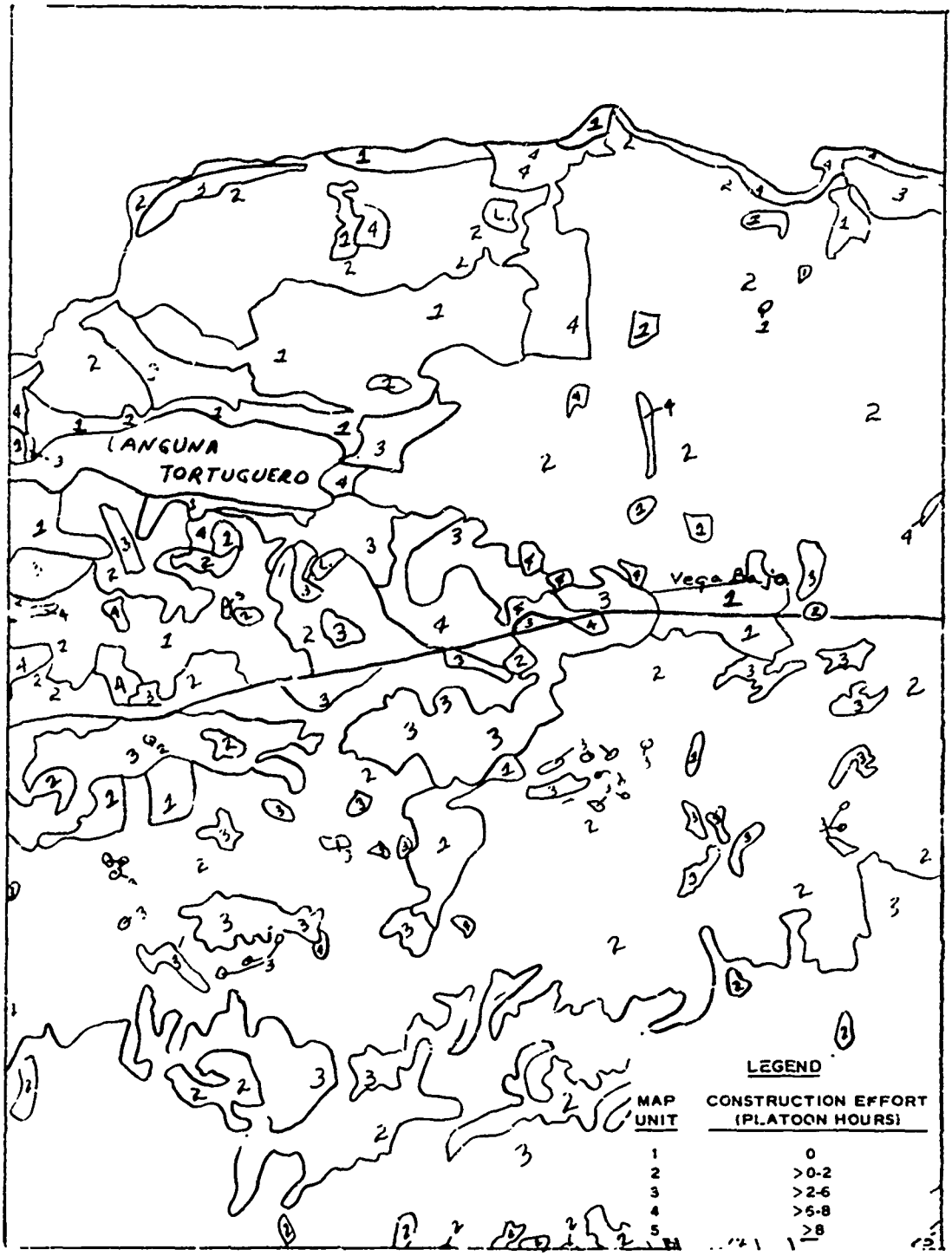


Fig. 48. MGI product map. HLZ construction effort

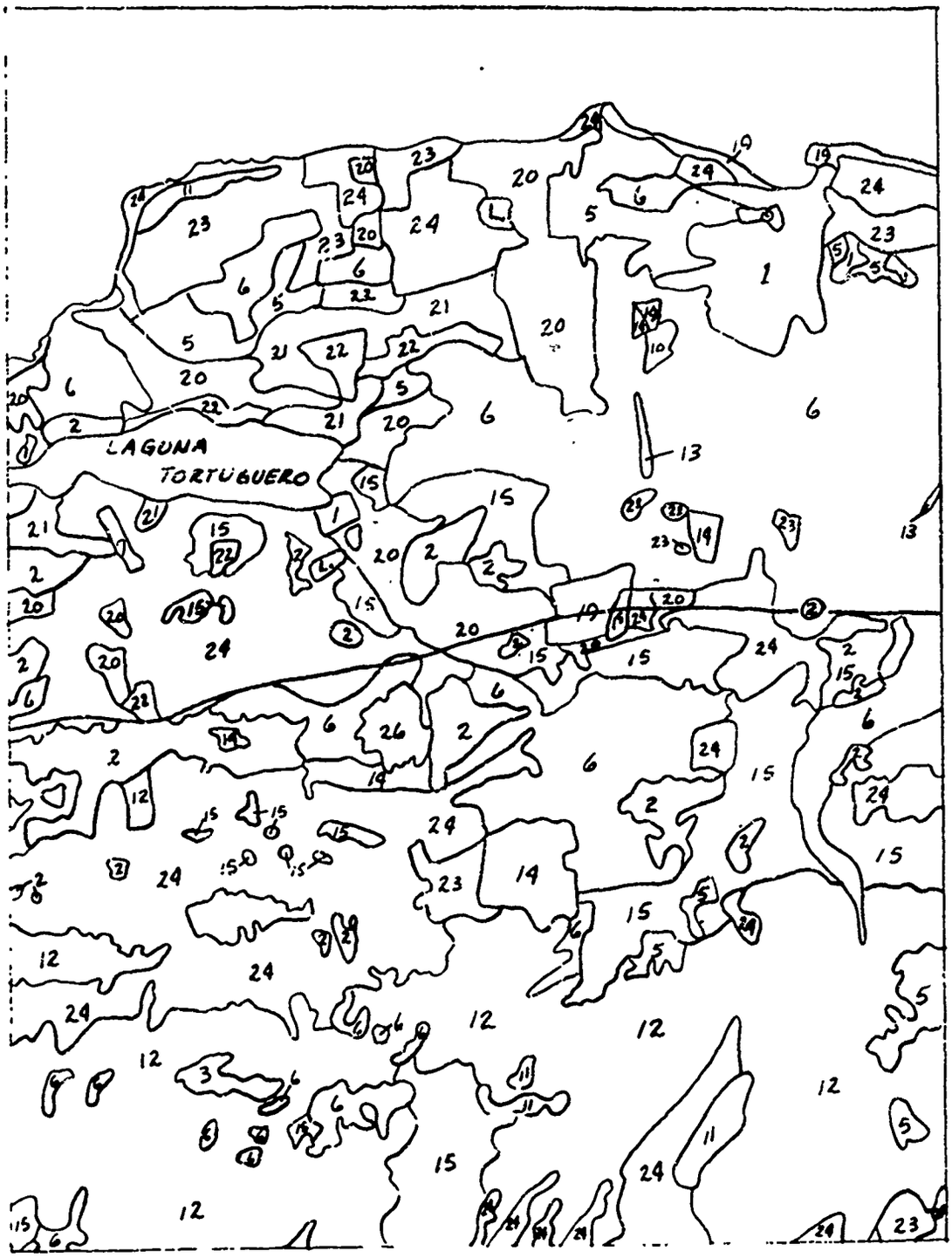


Fig. 49. MGI product map. Concealment characteristics (sheet 1 of 2)

Map Unit	Concealment Code (A)(B)(C)(D)	Map Unit	Concealment Code (A)(B)(C)(D)
1	1311	14	3311
2	1312	15	3312
3	1411	16	3322
4	1412	17	3411
5	2111	18	3412
6	2112	19	3511
7	2121	20	3512
8	2122	21	4211
9	2211	22	4212
10	2212	23	4511
11	2311	24	4512
12	2312	25	4522
13	2512		

Concealment Parameter Classes and Class Ranges

A. Probability of being observed from the air:

Class	Class Range, %
1	<5
2	>5-10
3	>10-35
4	>35-95

B. Distance at which the line of sight is totally obscured (100% probability):

Class	Class Range, cm
1	0-500
2	500-1000
3	1000-2000
4	2000-5000
5	>5000

C. Largest size of objects to be concealed:

Class	Class Range, m
1	15 x 30 x 200 (man)
2	75 x 150 x 1000 (jeep)

D. Number of objects concealed/1000 m^2:

Class	Class Range
1	0-12
2	>12-35

Fig. 49. (sheet 2 of 2)

Fig. 50. MGI product map. Cover characteristics (sheet 1 of 2)

Map Unit	Cover Code (A)(C)(D)
1	1211
2	1212
3	1311
4	1312
5	2111
6	2112
7	2121
8	2122
9	2211
10	2212
11	2222
12	2311
13	2312
14	2322

Cover Parameter Classes and Class Ranges

A. Probability of projectile reaching an effective height:

Class	Class Range
1	0-60
2	60-100

B. Distance at which all fire is blocked:

Class	Class Range, m
1	0-20
2	>20-40
3	>40

C. Largest size of objects to be covered:

Class	Class Range, cm
1	15 x 30 x 200 (man)
2	75 x 150 x 1000 (jeep)

D. Number of objects covered/1000 m^2:

Class	Class Range
1	0-12
2	>12-35

Fig. 50. (sheet 2 of 2)

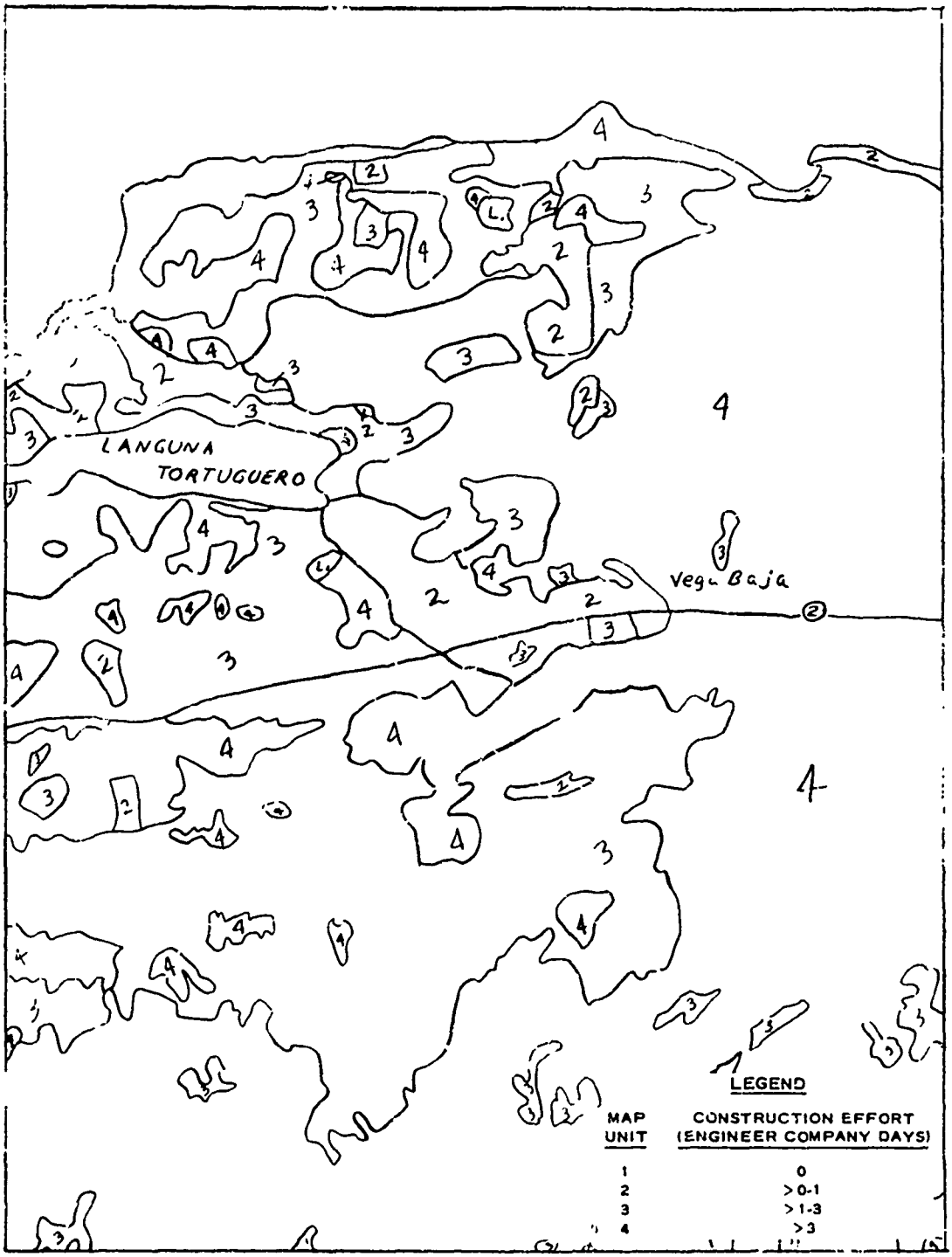
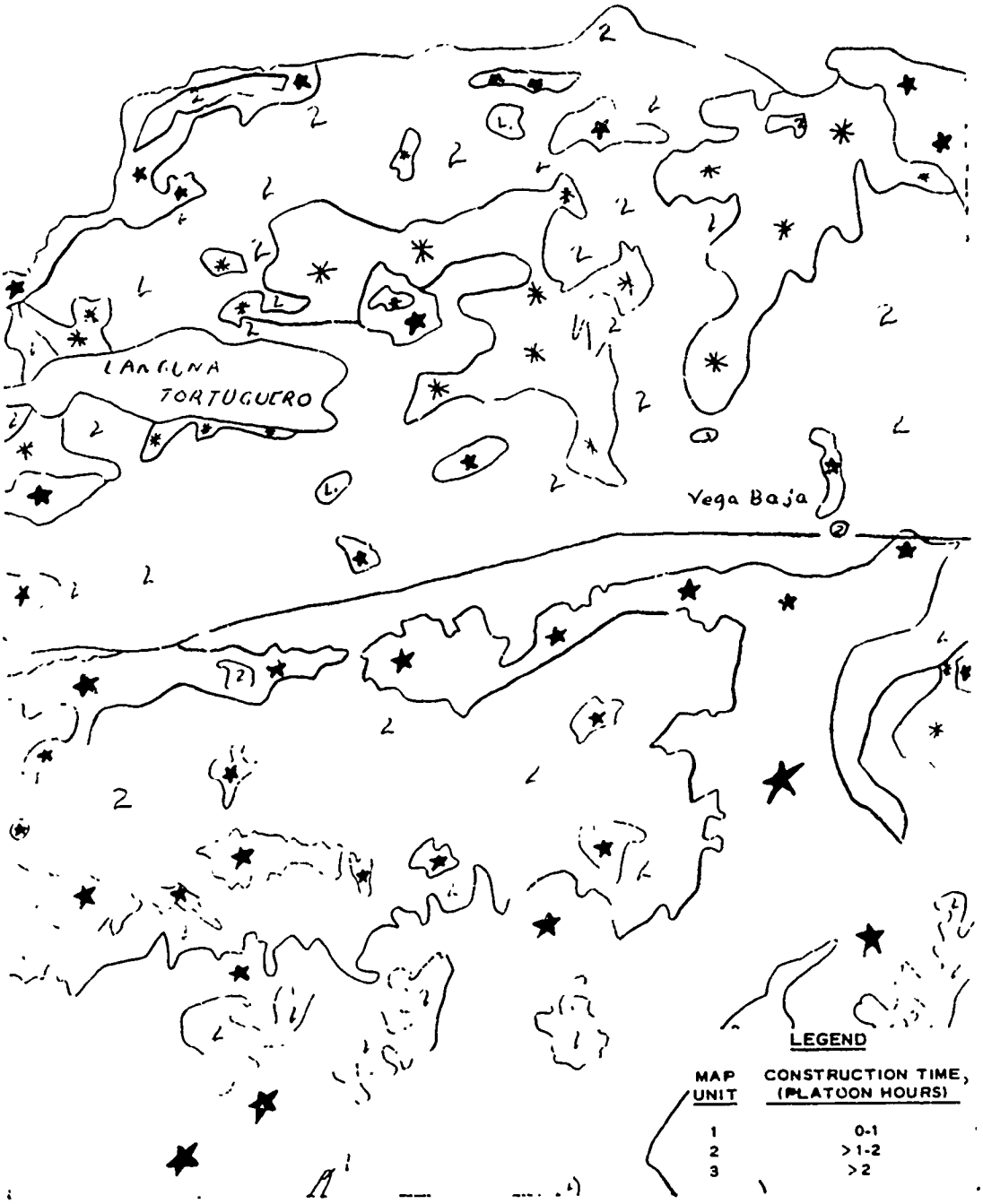


Fig. 51. MGI product map. Airfield construction effort



* Water table too high for bunker construction.
★ Rock -- bunker construction impossible.

Fig. 52. MGI product map. Bunker construction effort